SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY 1923.

GENERAL PHYSICS.

600. *Developments in Physical Science.* **A. Russell.** (Phys. Soc., Proc. 35. pp. 1–9, Dec., 1922. Presidential Address.)—The author deals with various physical developments, including the quantum theory, relativity, series in line spectra, the electron and the atom, and refers to certain technical applications of physics. W. R. C.

601. *Matter, Modern Tendencies.* **C. E. Guye.** (Arch. des Sciences, 4. pp. 269–296, July–Aug., 1922.)—An interesting *résumé* of modern tendencies towards the electromagnetic, the discontinuous, the statistical, and the metaphysical (relativity) and generally towards unity. A. D.

602. *Simultaneity.* **A. Schidlof.** (Soc. Phys. Hist. Nat. Genève, 39. pp. 47–49, April–July, 1922. Supplement Arch. des. Sciences, July–Aug., 1922.)—Simultaneity involves a symmetry which confines the observer to a particular point or line. A. D.

603. *Lateral Vibrations of Bars of Conical Type.* **D[orothy] Wrinch.** (Roy. Soc., Proc. 102. pp. 493–508, Sept. 1, 1922.)—The author shows that in the lateral vibrations of a conical bar vibrating with a free end, whatever the conditions at the base may be, the nodes in the nth tone occur at intervals of order $1/n$ in the neighbourhood of the base, and at intervals of order $1/n^2$ in the neighbourhood of the tip. W. R. C.

604. *Length of a Bar in Various Positions.* **G. Dimmer.** (Akad. Wiss. Wien, Ber. 129. 2a. pp. 223–252, 1920.)—Mathematical and experimental paper. A. D.

605. *Density Determinations of Metals and Alloys, Solid and Liquid, III. Dilatometer Method. System Sn-Bi.* **K. Bornemann** and **P. Siebe.** (Zeits. f. Metallkunde, 14. pp. 329–334, Aug., 1922.)—Parallel with the buoyancy experiments, the authors (along with M. Wehle) applied a dilatometer method. The charge is placed in a quartz bulb, from which a vertical tube rises, wide enough to allow of lowering another finer quartz tube, attached to a frame, into the vessel. This latter tube serves as sheath for two wire electrodes and a small tube through which nitrogen is introduced. The bulb is placed vertically in an electric furnace. When the substance is fused, the electrode tube is lowered until it touches the fluid metal; a buzzer then sounds. From the height of the known mass of liquid metal in the bulb of known volume and the temperature, the volume and expansion of the metal are deduced. Comparative experiments with tin and bismuth and with various Sn-Bi alloys show that the method is applicable at any rate up to 800° C., and when the bulb can be sacrificed, at higher temperatures. Details of the mode of filling the bulb, etc., are given. H. B.

606. *Demonstration of Stationary Waves in Electrically Heated Wires.* **A. Imhof.** (Phys. Zeits. 23. p. 262, July 1, 1922.)—When a metal wire, such as Fe, Ni, Cu, Pt, Cr-Ni, etc., is heated by means of low-frequency alternating current, the wire undergoes repeated alterations of length, which result in stationary waves clearly visible by reason of the extra cooling of the loops compared with the nodes. The author finds that, *e.g.*, a platinum wire of 0·1 mm. diameter gives waves of length 4·5 cm. The amplitude of swing is generally between 0·5 and 2 mm., but may reach 10 mm. J. W. T. W.

607. *Mechanics of Optical Polishing.* **E. Thomson.** (Optical Soc. of America, J. and Rev. Sci. Inst. 6. pp. 843–847, Oct., 1922.)—The ordinary view regarding the polishing of glass does not go far enough. Unlike the case of the burnishing of plastic metals, there is no flow of a hard, brittle, non-malleable substance like glass during polishing. The considerations given here are applicable to all processes, but rouge polishing with pitch for carrier is mainly discussed. In this the surface of the pitch is moulded to fit the glass and usually divided into small square facets by grooving. It is worked over the glass in all directions so that no definite course is repeated. The very hard rouge is friable and breaks down into fine powder; non-friable rouge tends to give fine scratches. The pitch is made yielding by tempering; it also, if too hard, causes fine scratches. In both cases under a magnifier the scratches show as smooth-bottomed grooves. In polishing, the surface is clean-cut in a kind of planing process, the particles of rouge set themselves into the pitch surface and cut smoothly. There is a further condition which has not hitherto been noticed. The particles doing the cutting are automatically adjusted in successful work to cut to the same depth in any stroke. The yielding nature of the pitch surface ensures this, for any particle of rouge riding higher than another is depressed to the proper level. The innumerable cutting edges reach a common level and with the motion of the polisher in all directions the result is an optical surface. T. H.

608. *Elastic Behaviour of Nickel at High Temperatures.* **W. Del Regno.** (Accad. Lincei, Atti 31. ii. pp. 105–108, Sept., 1922.)—A previous note dealt with the variation in the tenacity of nickel according to whether its temperature is below or above that corresponding to the magnetic transformation. Similar conclusions may be drawn if reference be made to the effective limit tension, *i.e.* to the relation between the maximum charge and the section of fraction. The results of the experiments may be summarised as follows: (1) In passing from the magnetic to the non-magnetic state, nickel shows a departure from the law of variation of tenacity with temperature. (2) This passage is very slow. It takes place in the interval between 300° and 400°, in which the substance displays an almost constant elasticity, *i.e.* the same elastic dilatation and a very slight variation of the limit tension. (3) The discontinuities in the dilatation are greater and more sharply defined as the temperature rises, reaching their maximum in the neighbourhood of 300°. At higher temperatures, in the case of non-magnetic nickel, they disappear. (4) Heating up to 400° increases the ductility, the metal becoming more malleable and only slightly less tenacious.

E. F.

609. *Elasticity of Metals and Alloys at High Temperatures. Young's Modulus.* **K. R. Koch** and **R. Dieterle.** (Ann. d. Physik, 68. 5. pp. 441–462, Aug. 31, 1922.)—Young's Modulus at temperatures up to 1000° C. was measured by observing the time of vibration of thin strips. The temperatures were obtained by surrounding the strips with a coil of tungsten wire through which an electric current was passed, the whole being contained in an evacuated tube, and measured by means of a thermo-couple. E decreases with increase of temperature, the rate of decrease increasing as the temperature rises. Values of E(Kg./mm.^{2}) are as follows:

Tin ...... from	3570	at 14° C. to	2695	at 203° C.
Lead	2010	13	1560	250
Aluminium	6155	17	2855	493
Gold	5650	12	4080	600
Iron	14,450	12	10455	600
Nickel	17,140	12	9885	1000
Duralumin ...	6030	12	4325	500
Brass	7435	12	4815	600

Though these results are not strictly comparable with previous ones on the torsion of wires, owing to the effect of drawing on the elastic properties, yet there is evidence that Poisson's ratio increases with temperature.

W. G. B.

610. *Temperature and Gravitation.* **P. E. Shaw** and **N. Davy.** (Roy. Soc., Proc. 102. pp. 46–47, Oct. 2, 1922.)—Previous work [Abstract 860 (1916)] had led to the conclusion that the Newtonian constant of gravitation increases slightly as the attracting bodies are heated. With improved suspension arrangements, the difference previously observed disappears.

A. D.

611. *Periodic Annual Variation in the Rate of a Pendulum.* **R. Goudey.** (Comptes Rendus, 175. pp. 748–750, Oct. 30, 1922.)—The author investigates the going of a pendulum (Fenon 45, of the Observatory of Besançon) placed in a ground-floor room, enclosed in a double glass case, so that the temperature varies slowly, but subject to variations of atmospheric pressure. Taking numbers corresponding to the "mean state" of the pendulum for 36 equal divisions of a year in which the pendulum has been untouched and not cleaned, the author gives curves for the years, 1905, 1906, 1908, 1909, 1911, 1912, 1914, 1915, 1917, 1918, 1919, and 1921. These show a first maximum near the division 10, a second between 20 and 25, and a minimum about 32. Each year the pendulum goes slow about April 11; from that date till Sept. 11 there are a series of fairly indefinite fluctuations, and subsequently, the pendulum moves at its mean rate until near the end of the year. The movements can be represented by a curve, and cannot be explained either by changes of temperature or pressure, or by mere chance. A. S. D. M.

612. *Vacuum Gravitation Needle.* **C. Barus.** (Nat. Acad. Sci., Proc. 8. pp. 313–316, Oct., and pp. 327–330, Nov., 1922.)—The first paper records the static deflections, logarithmic decrements, and first half period of the vacuum gravitation needle. The second paper deals with the slight differences in equilibrium positions in the years 1921 and 1922. The value of the original papers lies in great measure in the very intricate graphs showing the minute quantities in question. [See Abstract 1465 (1922).] E. H. B.

613. *Tensions and Pressures in the Boundary Surfaces, and Surfaces of Separation of a Fluid. Swelling Phenomena.* **H. Hulshof.** (Ann. d. Physik, 17. 4. pp. 278–300, May 23, 1922.)—The present paper is an attempt to find an explanation for the origin of swelling, this being regarded as a capillary phenomenon. The starting point of the investigation is the assumption that the sum of the pressure and the molecular pressure (a consequence of molecular attraction) at any point of a fluid has the same value in all directions, and, like the entropy, is determined only by the density and temperature at the point. The energies are then derived for points in the various transition surfaces which occur in fluids; and then the various surface tensions. The results obtained correspond to the thermodynamic theory of capillarity, and afford an insight into the origin of capillary phenomena as a consequence of tensions and pressures in the transition layers. Application is then made to the phenomena of swelling in colloidal media. The paper is entirely mathematical. H. H. Ho.

614. *Measurement of Impulsive Pressures.* **J. J. Dowling** and **J. J. McHenry.** (Beama, 12. pp. 82–86, Feb., 1923.)—A simple and compact type of manometer for measuring impulsive pressures is described. A steel diaphragm, exposed to the pressure wave, yields and closes an electric circuit, contact being made between a stud carried by the disc and a short steel rod carried by a second disc, provided the pressure attains a predetermined minimum value. The occurrence and duration of the contact are indicated electrically, and means are provided for adjusting the pressure of response. [See also Abstract 792 (1919).] J. S. G. T.

615. *Conditions Governing the Definition of Quantity.* **F. London.** (Phys. Zeits. 23. pp. 262–268, July 1, and pp. 289–295, July 15, 1922.)—A general discussion of the bases underlying the accepted system of quantity definition of physical entities and the equations relating them to one another. The author considers Tolman's principle of similitude [see Abstracts 1488 (1915) and 975 (1916)]. The paper is a discussion of mathematical principles and cannot be usefully abstracted.

Erratum [*ibid.* p. 392, Oct. 1, 1922]. J. W. T. W.

616. *Shape of a Piston Packing Ring.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 4. pp. 149–154, July, 1922. In English.)—The author shows how to determine the shape of a piston packing ring which will exert a constant normal pressure on the cylinder well in contact with it, and the normal pressure on the wall of a ring of given shape. The analysis is a slight extension of that developed by H. Lamb (Lond. Math. Soc., Proc. 13. pp. 365, 1888). Consider the ring as a thin curvilinear bar, which, when unstrained, is a circle of radius a. Taking the centre as origin, suppose a point a, θ to be displaced after deformation into $a + \mathrm{R}$, $\theta + \Theta$. The potential energy in the strained state will then be $1/2a \,.\, \int \mathrm{B}(\theta)\left\{d\Theta/d\theta + d^3\Theta/d\theta^3\right\}^2 d\theta$, where $\mathrm{B}(\theta)$ is a quantity depending on the elasticity and the cross-section of the ring. When the latter is rectangular with its breadth in the plane of distortion $b(\theta)$ and its thickness h, $\mathrm{B}(\theta) = \mathrm{E}h\left\{b(\theta)\right\}^3/12$, where E is Young's modulus for the material. Then, where P is the radial component per unit length of the forces acting on the ring, the equation of equilibrium is shown to be $d^2/d\theta^2\left\{\mathrm{B}(\theta)(d\Theta/d\theta + d^3\Theta/d\theta^3)\right\} + \mathrm{P}a^3 = 0 \ldots$ (A). From this it is shown that when the ring, of radius a when unstrained, is placed inside a circular cylinder of radius less than a by a small quantity δ, then, for h constant, the best shape for the packing ring is determined by the equation $b(\theta) = a\left\{12\pi \mathrm{P}/\mathrm{E}h\gamma . [\cos(\theta + \gamma) + 1]\right\}^{1/3}$, where $\gamma = \pi\delta/a$. From (A) may also be found the pressure P when the shape of the packing ring is given. Take, *e.g.*, the Ramsbottom packing ring, formed by cutting out of a disc a ring made up of two circles of radii a and b, the centres of which are separated by a small distance k. If ρ be the length of the radius vector from the centre to the edge of the ring, its thickness $a - \rho \doteqdot a - b - k \cos\theta$, and then the equation A, together with the condition $d\Theta/d\theta + d^3\Theta/d\theta^3 = \delta/a$, express $d\mathrm{P}/d\theta$ as a function of θ, which on integration gives

$$\mathrm{P} = -\,\mathrm{E}\delta h k^2/4a^4 \,.\, \left\{2k \cos 3\theta/3 - 3(a - b)\cos 2\theta/2\right\}.$$

Thus in the Ramsbottom ring P is not constant, but a function of θ.

G. W. DE T.

617. *Flow of Liquids under Capillary Pressure.* **E. K. Rideal.** (Phil. Mag. 44. pp. 1152–1159, Dec., 1922.)—The rate of penetration of a liquid into a fine capillary under its own forces is expressed by

$$t = \frac{2\eta}{\gamma r}x^3 - \frac{\delta r^2}{8\eta}\log x.$$

For relatively large capillaries the penetration coefficient is $\sqrt{\gamma r/2\eta}$. The experimental determination of the coefficient agrees with the calculated values. In the case of mixed solvents the dynamic and not the static surface tensions are probably the governing factors. The reciprocal of the penetration coefficient is proportional to the square root of the period of molecular relaxation as defined by Maxwell, and on analogy with reactions in the solid state is probably important in reactions taking place in liquid media.

A. D.

618. *Cylindrical Journal Lubrication at High Values of the Eccentricity.* **T. E. Stanton.** (Roy. Soc., Proc. 102. pp. 241–255, Dec. 1, 1922.)—An investigation to obtain more definite information on the nature of the action between two lubricated surfaces when the value of the intensity of the pressure as defined by load/(area of lubricated surface) is considerably higher than that normally attained with cylindrical journals. In the case of worm gears it has been suggested that the thickness of oil between the surfaces of molecular dimensions, hence the interaction of these molecules with the molecules of the surfaces determine the nature of the frictional resistance to motion. This is termed "Boundary Lubrication." In the experiments undertaken a journal of tool steel 1 inch in diameter and 3 inches long, hardened and ground, was used, the bearing being a cylindrical phosphor bronze bush carefully bored and lapped. The values of the pressure of the oil film were obtained by connecting a small hole in the centre section of the bearing to a Bourdon gauge. The temperature of the film was measured by inserting a thermo-junction in the pressure hole, after determining the pressure, so that the end of the junction was in contact with the surface of the revolving journal; a small amount of oil being allowed to leak through the oil way by means of a special gland. The results of experiments with a journal 1·00 inch diameter and bearings of 1·02 inch diameter and 1·06 inch diameter are given, together with the calculation of eccentricity. A series of tables at the end of the paper presents the results of this investigation. [See Abstract 1478 (1922).] T. C. H.

619. *Spreading of Liquids and Spreading Coefficient.* **W. D. Harkins and A. Feldman.** (Am. Chem. Soc., J. 44. pp. 2665–2685, Dec., 1922.)—This paper deals with the spreading of liquids on liquids and solids, and the relation between the spreading coefficient and the interfacial and surface tensions. The various terms used in the theoretical discussion are defined, experimental methods are described, and the results of determinations made with various classes of liquids are given. The paper does not lend itself to abstracting, and the original must be consulted for details. F. J. B.

620. *Effect of the Variable Head in Viscosity Determinations.* **F. M. Lidstone.** (Phil. Mag. 44. pp. 953–955, Nov., 1922.)—The author acknowledges the criticism of an earlier paper [Abstract 2039 (1922)] from W. H. Herschel, G. Barr, and L. F. G. Simmonds, that the logarithmic head correction in the viscous term of the equation is, strictly speaking, incomplete, inasmuch as it is based on the assumption that the head varies directly with the velocity, and a necessary correction from Barr in the final kinetic energy term of the approximate equation. The latter is embodied in equation (2) of this paper. With respect to the former, the author states that as no attempt appears to have been made to find a general equation embracing all these corrections, it is here proposed to try to find the exact expression in order to ascertain to what extent the ordinary formulæ are in error. The premises of the argument are included in the generally accepted equation

$$\eta = \pi r^4 gpth/8Vl - V\rho/8\pi lt,$$

the coefficient of the K.E. term being taken as unity. This equation is true provided the head h is constant; but unless some compensating mechanical contrivance is used, *e.g.*, that of Hyde [Abstract 1121 (1920)], this condition is never absolutely realised in practice, as when flow starts there is necessarily change in the hydrostatic head. The investigation gives a solution for η which would lead to a number of very unwieldy power series. But it also suggests an approximation requiring the computation of three or four terms of a rapidly converging series. Applied to one of the standard runnings of water at 20° C., with all the data in detail in Archbutt and Deeley's "Lubrication and Lubricants," 3rd edition, this approximation gives the value of η as 0·01006818 as compared with 0·0100721 obtained from the ordinary formula. The difference is not striking, but this was to be expected in that while there is a considerable fall in the head, the kinetic energy term is small. In order adequately to demonstrate the shortcomings of the ordinary formulæ, it would be necessary to make a running under a considerably increased initial head, so that the K.E. correction should become appreciable, and to continue the running until the final head was relatively small. G. W. de T.

621. *Application of an Optical Manometer to the Measurement of the Viscosity of Gases.* **J. E. P. Wagstaff.** (Phil. Mag. 45. pp. 84–88, Jan., 1923.)—A delicate form of optical manometer, recently described by the author (see Proc. Camb. Phil. Soc., vol. xx. Part I), has been used as a pressure-gauge for measurements of the viscosity of air. This method of measuring small changes of pressure has been found to possess considerable advantages over the usual method adopted in this type of experiment of taking two simultaneous readings of a moving mercury column. The apparatus and method of use are now described together with the contingent theory, the viscosity being found dependent on the time taken for a given number of circular fringes to close in towards their centre. Sets of experimental results are included. H. H. Ho.

622. *An Improved Optical Lever Manometer.* **E. K. Carver.** (Am. Chem. Soc., J. 45. pp. 59–63, Jan., 1923.)—While considering measurements on the adsorption of toluene vapour by plane glass surfaces, none of the manometers described in the literature was found to be entirely suitable. The McLeod gauge is inaccurate with easily condensable vapours, the hot-wire manometer is hardly sensitive enough, the thermionic pressure gauge decomposes the toluene, and the use of Knudsen's apparatus offered many difficulties. The Rayleigh manometer and the optical lever instrument of Shrader and Ryder appeared the only ones suitable, and the latter was found by experiment to be preferable. This is described at length in the paper together with a few modifications whereby the sensitivity has been increased to about 0·0001 mm., with an accuracy of about 0·0002 mm. of mercury. H. H. Ho.

623. *Absolute Dimensions of the Karman Vortex Motion.* **W. Heisenberg.** (Phys. Zeits. 23. pp. 363–366, Sept. 15, 1922.)—This paper deals with an investigation of Karman [see Abs. 294 (1912)] concerning the current phenomena when a plane plate is moved with a given velocity perpendicular to its plane through water. Behind the plate a series of vortex movements were found, and the present author now deduces their dimensions. The paper is entirely mathematical and includes a criticism by Prandtl. H. H. Ho.

624. *On the Oscillations of Certain Electrical or Mechanical Systems due to a Periodic Impressed Force.* **I. Herlitz.** (Gen. El. Rev. 25. pp. 686–689, Nov., 1922.)—This paper considers the fundamental equation for the force oscillations of an oscillatory system, *viz.* $a d^2y/dt^2 + b dy/dt + cy = f(t)$, where in an electric circuit consisting of inductance, resistance, and capacity in series, y may be the charge on the condenser, in which case $f(t)$ is the impressed electromotive force, a the inductance, b the resistance, and $1/c$ the capacity of the circuit. In a corresponding mechanical problem of great interest to electrical engineers, y is the angular displacement of the rotor of a synchronous machine from its average position, while $f(t)$ is the variable component of the torque acting on the shaft, a then is the moment of inertia of the rotary system, b corresponds to a damping force, and c to the "synchronising force." A very interesting and unusual method of solution is described, and a numerical example given in illustration. The paper itself, which should be consulted in its entirety, is mathematical throughout, and the investigation is claimed as affording an illustration of advantageous co-operation between industry and college. H. H. Ho.

625. *Analysis of Damped Vibrations.* **H. S. Rowell.** (Phil. Mag. 44. pp. 951-953, Nov., 1922.)—The primary difficulties are the nature of the friction and the position of the zero. In practice we can generally assume the presence of both solid friction, a constant, and fluid friction, proportional to the velocity, and therefore take, as the equation of motion, $m\ddot{x} + k\dot{x} + c^2x \pm F = 0$, the sign of F to be that of $\dot{x}$; put $x = X \mp F/c^2$, and the solution is $x = \mp F/c^2 - A_0e^{-kt/2m} \cos n't$; where $n' = \sqrt{n^2 - k^2/4m^2}$, $n^2 = c^2/m$, $F/c^2 = S$ and $k\pi/2mn' = \lambda$; so that $e^{-\lambda} = \delta$, the logarithmic decrement for half periods. Assume a datum line at distance E from the true time axis, and let R_i be the reading from this datum corresponding to the ith half swing; $R_0 = E - S - A_0$ (1), $R_1 = E - S' + A_0\delta$ (2), $R_2 = E + S - A_0\delta^2$ (3), $R_3 = E - S + A_0\delta^3$ (4), $R_4 = E + S - A_0\delta^4$. Subtract (1) from (2), (4) from (2), (3) from (5), giving, respectively, (6), (7), (8). Divide (8) by (7), giving (9), and substitute in (6), giving $A_0 = (R_1 - R_0)(R_1 - R_3)/(R_1 - R_2 - R_3 + R_4)$. Divide (7) by (6) and add to (2) + (3), giving

$$2E = R_1 + R_2 - (R_1 - R_3)^2/(R_1 - R_2 - R_3 + R_4),$$

giving the position of true zero. The solid friction term S follows from (1), and since c^2 is easily found statically, F the solid friction of the system per unit mass follows by division. When the system is dead beat, this method fails, but a solution can be obtained by tuning of the system by adding mass or increasing c^2, or both, so that sufficient equations are determined for elimination. The author points out how, by aid of a former paper [Abstract 263 (1923)] the curve may be constructed of which the vibration here considered is the projection. The essential difference between solid and fluid friction is that in the former the dissipation per cycle is proportional to the amplitude, and in the latter to its square. Since the energy of motion varies as the amplitude squared, the dissipation per unit time with fluid friction is a constant fraction of the energy of the system, but with solid friction the dissipation as a fraction of the total energy is inversely as the amplitude. Hence in solid friction the rapid damping of small vibrations until finally the dead region of width $2F/c^2$ is reached. Clearly in the two systems the envelopes of the two vibration curves may be tangential, in which even solid friction may be mistaken for fluid friction. As the foregoing analysis indicates, five half vibrations or two complete periods suffice not only to safeguard against this possibility, but also to apportion the relative magnitudes of the two sets of frictional forces. It seems possible that some such analysis as is here outlined may be a useful instrument of investigation in connection with friction and lubrication, affording at least some sort of criterion in so-called border-line cases. G. W. de T.

626. *Motion of Sphere in Rotating Liquid.* **S. F. Grace.** (Roy. Soc., Proc. 102. pp. 89–111, Oct. 2, 1922.)—A sphere of uniform density is supposed to be suspended in a uniformly rotating liquid of the same density. An initial relative motion of the sphere parallel to the axis of rotation is set up by an instantaneous impulse sufficient only to effect a small disturbance in the motion of the system, small motion being defined to be such that the squares and products of velocity and vorticity components may be neglected in the expressions for acceleration. The initial disturbed motion of the liquid will then be irrotational, since the effects of rotation take time to develop. Now the pressure intensity of the liquid consists of two parts, one depending only on the distance from the axis, and the other on the disturbed motion. When the disturbance causes the sphere to move parallel to the axis of rotation, the disturbed motion of the liquid will continue symmetrical about a line through the centre of the sphere parallel to this axis, and the motion pressure of the liquid will also be symmetrical about this line. The resultant effect on the sphere will, therefore, be to produce an acceleration parallel to the axis of rotation, causing the sphere to continue its motion parallel to the axis of rotation, and its line of relative motion may be called the axis of the sphere. The method of discussion will be to assume the existence of this particular type of motion, and then to show that all the conditions can be satisfied by making it a particular function of the time, a perfectly definite mathematical problem, the solution of which gives the following results: The sphere oscillates about a point on its axis, the distance of which from the initial position of the centre of the sphere is proportional to the velocity of projection; the amplitude of oscillations rapidly approaches zero, but the period approaches a constant value half that of the undisturbed rotation of the liquid. A general expression is obtained for the velocity, at any point, reducing to simple expressions in particular cases, which are examined in the paper. It appears, however, that the gradients of the velocity of the liquid over the equatorial plane of the sphere and of the transverse velocity along a meridian of the sphere ultimately increase without limit, a stage being reached after which vorticity components cannot be considered small, so that the solution will represent the true state of the liquid only for a limited time. The question of the ultimate physical state thus remains unanswered. J. Proudman has shown [Abstract 977 (1916)] that a small steady disturbance is impossible, but G. I. Taylor [Abstract 715 (1922)] obtained a solution of the general equations of steady symmetrical motion about a sphere, which does not satisfy the equations of small motion. Whether or no Taylor's solution represents the ultimate state in the problem of the present paper is a question for further investigation. G. W. de T.

627. *Mutual Threading of Vortex Rings.* **W. M. Hicks.** (Roy. Soc., Proc. 102. pp. 111–131, Nov., 1922.)—A mathematical paper, in which equations are developed expressing the conditions for permanent union with parallel straight vortices, two circular rings, rings of different, and opposite, circulations. A graphical construction representing the curves of the relative orbit is shown. A. B. C. L.

628. *Sailing Flight in the Mediterranean.* **H. Fabre.** (Comptes Rendus, 175. pp. 1042–1044, Nov. 27, 1922.)—(1) *Flight Parallel to the Troughs of the Waves.*—Observations are given on the flight of a bird called a diver by sailors and fishermen, but probably a puffin. It has a wing spread of about 70 cm. When forced to do so, it cleaves the air like a duck, but when the wind attains a speed of 10 m. per second and the hollow of the waves a depth of 50 cm. it sails, skimming the water at a height of 10 or 20 cm. Its speed appears to exceed 15 m. a second. It oscillates with extreme rapidity about its longitudinal axis, giving as it were sudden twists of the rudder which propel it in tiny zig-zags of which the total effect is rectilinear. The explanation of this flight is based on the hypothesis that the wind passing over the waves is deflected by them just as hills cause ascending currents utilised by motorless gliders. Each molecule may be supposed to describe in a vertical plane a curve analogous to a sinusoid. The upward and the downward current are equal in quantity, but the wind rises on one side of the sinusoid and falls on the other, and the bird steers its course over the upward current. (2) *Flight at Right Angles to the Troughs of the Waves.*—The gull sails less than the diver and is more given to cleaving the air, but with a wind of 15 m. per second and a very choppy sea with a minimum trough of 75 cm., it ceases to flap its wings and heads the wind at a height of usually less than 1 m. above the crests of the waves. A sinusoidal trajectory of the wind would appear to explain this flight. Let us consider the gull placed in this sinusoidal current and heading the wind. It is in a soaring posture and does not flap its wings. Let us then consider it flapping its wings in a calm. The wings may be supposed to describe a sinusoidal trajectory. In the first case the air is displaced in relation to the wing, in the second the wing is displaced in relation to the quiescent air. The speed of the air in relation to the wing is in each case the same and the effect on the wing identical. We may thus conclude that if the bird placed in a sinusoidal current change the inclination of its wings to the horizontal, as it does in cleaving the air, it will be supported in exactly the same way. E. F.

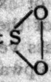
629. *The Michelson-Morley Experiment.* **G. Dalla Noce.** (N. Cimento, 24. pp. 17–27, July–Sept., 1922.)—Recension of Righi's treatment of the problem. Assumes no bands visible unless the apparatus be thrown slightly out of symmetry. A. D.

630. *The Michelson-Morley Experiment.* **J. Alliata.** (Arch. des Sciences, 4. pp. 358–361, Sept.–Oct., 1922. Paper read before the Soc. Suisse de Physique.)—Criticism of Michelson and Morley's methods. A. D.

631. *Stresses in a Circular Ring.* **S. Timoshenko.** (Phil. Mag. 44. pp. 1014–1019, Nov., 1922.)—The author obtains the stress distribution in a circular ring compressed by two forces acting along a diameter. Considering the problem as a two-dimensional one, he obtains the solution by combining the known solutions of the problem of compression of a disc and that of a ring, both of uniform thickness. The calculations

have been made by Runge's method of approximation. He finds that six terms only of the series are sufficient to determine the stresses with an error not exceeding a half per cent. Curves are given showing the normal stresses in the vertical and horizontal cross-sections of a ring when $R = 2r$ as so calculated. Dotted curves on the same figure represent the results of elementary solutions obtained by using the hypothesis of plane cross-sections or of plane distribution of normal stresses. It is pointed out that the method may be applied to the more general case of a circular ring subjected to any forces acting on its external rim, it being necessary merely to use the corresponding solution for a disc.
G. W. DE T.

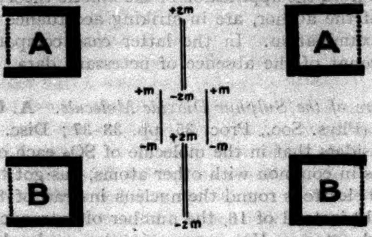
632. *Viscosity and Molecular Dimensions of Gaseous Carbon Oxysulphide (COS).* **C. J. Smith.** (Phil. Mag. 44. pp. 289–292, Aug., 1922.) —On the assumption of the validity of the Lewis-Langmuir view of molecular constitution, the probable behaviour during encounters has been examined for the molecules of carbon oxysulphide and carbon bisulphide. In the former case it is shown that the molecular dimensions, as derived from the application of the kinetic theory to the viscosity measurements of the author, are in striking accordance with the results of the above examination. In the latter case comparison is not yet possible, on account of the absence of necessary data. AUTHOR.

633. *Structure of the Sulphur Dioxide Molecule.* **A. O. Rankine** and **C. J. Smith.** (Phys. Soc., Proc. 35. pp. 33–37; Disc. 38, Dec., 1922.) —Langmuir considers that in the molecule of SO_2 each oxygen atom, by holding electrons in common with other atoms, has got the configuration of neon, with 10 electrons round the nucleus instead of 8; and sulphur, like argon, has 18 instead of 16, the number of extranuclear electrons in the uncombined atom. He represents the molecule as O═S—O, the single bond meaning that two electrons are shared and the double bond that four are shared. The authors consider this arrangement, and also the arrangement  in which six electrons are also shared between the atoms. Dimensionally it may be assumed that the molecule has the properties of a particular arrangement of two neon atoms and one argon atom, the radii of the collision spheres of which, as determined by viscosity measurements, are 1·44 Å. and 1·15 Å. W. L. Bragg's crystal measurements lead to similar values for the radii of the outer electron shells. The mean area which any particular model presents in collision for all orientations can be calculated; and when this is done for the second of the above arrangements the value $0{\cdot}99 \times 10^{-15}$ cm.^{2} is found for the collision area. The value obtained from viscosity measurements is $0{\cdot}94 \times 10^{-15}$ cm.^{2}, which is sufficiently near to that of the model to enable the difference to be attributed to experimental errors and inexactitudes in the assumptions. The arrangement O═S—O is indeterminate, as the two oxygen atoms need not be at opposite ends of a diameter of the sulphur. It is shown that the mean area will always be greater than $0{\cdot}99 \times 10^{-15}$, which was the value obtained for the second arrangement; and it is concluded that the second arrangement is the correct one. The graphical method employed has been applied to COS and CS_2.

The mean collision areas are COS $1\cdot09 \times 10^{-15}$ cm.^{2}, CS_2 $1\cdot31 \times 10^{-15}$ cm.^{2}; viscosity measurements give $1\cdot06 \times 10^{-15}$ cm.^{2} for COS.

H. N. A.

634. *Lecture Room Demonstration of Atomic Models.* **L. V. King.** (Phil. Mag. 44. pp. 395–400, Aug., 1922.)—The apparatus described enables experiments to be made more successfully, and with less difficulty, than by employing Meyer's method, with floating and suspended magnets. Steel spheres, or soft iron rods, are made use of, in an alternating magnetic field. With a single coil, over the opening of which a watch-glass is placed containing the steel spheres, it is found that these become a.c. magnetic doublets, with very uniform magnetic moments, the instantaneous magnetic moments being equal in magnitude and phase. The spheres repel one another with a force varying as the inverse fourth power of the distance. The gravitational attraction to the lowest point of the watch-glass varies as the distance, and remarkably symmetrical stable groupings are formed. Two coils may be used, arranged as in the Helmholtz galvanometer, but placed one above the other so as to produce a very uniform field in the plane midway between them, and the steel balls may be floated in a dish of mercury placed between the coils. The system can be set in oscillation, by means of external magnets, in a manner suggestive of the internal vibrations of the atom. Small elongated pieces of iron, placed in a cylindrical glass vessel at the centre of the coil, make violent movements, jumping upwards and rebounding from the glass again and again. This may be used to illustrate Brownian movements, or the movements of molecules in a gas. Experiments on electrodynamic repulsion can also be carried out with the apparatus; and a model can be constructed by suspending short lengths of soft iron by silk threads attached to one extremity of each to represent the electrons; with two bundles of wires, to represent the nucleus, contained in a glass tube, placed as shown in diagram, where A A and B B are sections of the two coils, and each of the nucleus bundles consists of two wires representing a nucleus $2e$. The two suspended wires at the sides $+m$ $-m$ will behave like two electrons. In certain cases it is possible to project an "electron" wire, so as to describe a damped elliptic orbit about the "nucleus."



H. N. A.

635. *The Rectilinear Diameter of Neon.* **E. Mathias, C. A. Crommelin, and H. K. Onnes.** (Comptes Rendus, 175. pp. 933–935, Nov. 20, 1922.)—The density curves of neon, liquid and saturated vapour, were investigated between the critical point, − 228·71° C. and the normal boiling-point,

$-245 \cdot 92°$ C. The curves of O, A, N, and H have previously been determined. The same hydrogen cryostat was used as in the investigation of hydrogen, as there is no liquid which could be employed except that of neon itself. The "diameter" in question is not that of the molecule; but is the locus on the density temperature curve of the points $y = \frac{1}{2}(\delta + \delta')$, where δ is the density of the liquid and δ' that of the saturated vapour. This locus is, as in the case of the other gases investigated, approximately rectilinear. If y is calculated from the formula $y = - 1 \cdot 154406 - 0 \cdot 00716146\delta$, where δ is the temperature in degrees C., the greatest difference from the observed value is $0 \cdot 53$ %. The "slope of the diameter" is $a = - 0 \cdot 00716146$; this is an exceptionally large value. The critical density is $\Delta = 0 \cdot 4835$. The critical coefficient is $R\theta\Delta/\pi = 3 \cdot 249$, where R is the gas constant, θ the absolute critical temperature, and π the critical pressure; this is the smallest value which has been observed, though for helium the preliminary value $2 \cdot 68$ has been deduced. The deviations of the diameter from a straight line are such that at low temperatures it is slightly convex to the temperature axis, and at higher temperature slightly concave. This is also the case with argon, nitrogen, and carbon dioxide. As in all other gases studied at Leyden, the diameter shows a small deformation in the neighbourhood of the critical point.

H. N. A.

636. *Boron Hydrides.* **M. L. Huggins.** (J. Phys. Chem. 26. pp. 833–835, Dec., 1922.)—Structures are proposed for the compounds B_2H_6, B_4H_{10}, B_6H_{12}, and $B_{10}H_{14}$. These structures are analogous to those of the carbon compounds ethylene, butadiene, benzene, and naphthalene respectively. The hydrogen atoms are held by means of four-electron bonds, such as often exist (temporarily at least) in unsaturated organic compounds. Each such bond is surrounded by four atoms. W. R. C.

637. *Atomic Systems based on Free Electrons.* **R. Hargreaves.** (Phil. Mag. 44. pp. 1065–1105, Dec., 1922.)—Electrons and positive ions are assumed to be held in two concentric rings with or without one or two charges at the centre. The stability of systems containing n ions is investigated. For all values of $n \geqslant 4$, a single ion at the centre is stable. From $n = 2$–8 there can exist two axial ions spaced widely, so that the central force is less than that due to a single central ion. From $n = 5$–8 a second form is stable with two axial ions more closely spaced. For all values of n, the system is stable with no central or axial charges. Central or axial negative charges are not stable. The systems allow of the attachment of planetary electrons and so are a type of freely equilibrated nucleus. Such satellites can be held either within or without the rings. The relation between atomic number and atomic weight is investigated. Writing for internal motion: $N\epsilon^2 = m_1\omega^2a_1^3$ (ϵ, ionic charge; m_1, ionic mass; ω, angular velocity; a_1, radius of ionic ring), N is a function of n, shown by analysis to lie so that n/N ranges from $1 \cdot 909$ for $n = 2$ to $2 \cdot 266$ asymptotically. This ratio is regular, and irregularities are explained by the various forms stable with any value of n, several arrangements of planetary electrons and central charges being possible. Thus n^2/N is suggested as representing the atomic weight. A quantity M_n is defined then by $M_n = n/N$. Seeking to eliminate the gravitation constant by changing the mass unit from M_n to Mg, leads to the relation $Mg = 3872m_2$ (m_2 = electronic mass) or

$Mg = 2\cdot 1 m_1$. This constant is nearly the average value of n/N. Another numerical relation is indicated by the equality of $\gamma m_1^2/m_2^2$ and $\frac{1}{2}(0\cdot 44127)$, the limit of $N/2n$. Thus the coefficient in $N/2n(n^2e^2/a_1)$, an expression for internal kinetic energy, approaches asymptotically that in $\gamma(m_1 + m_2)^2/m_2^2 \times (n^2m_2^2/r)$, a gravitational potential. Equating these gives $m_1 = 1818m_2$. Millikan's value is $m_1 = 1832m_2$.

Consideration of the stabilities and vibrations of such systems is given for the case $n = 2$ and when n is large. The range of ionic frequencies agrees broadly with the range of the K (γ) series. The electronic vibrations cover a much larger range. Tangential displacements are in a sense unstable. Each electron will apparently describe a loop round an adjacent ion before reaching another equilibrium position. The radiation will be mostly confined to this looped portion of the movement. Thus an approach to discontinuous radiation is obtained, which may be correlated with Bohr's theory of stages. Mathematical analysis of the conditions of stability and oscillations is given and n/N is tabulated.

A. Wh.

638. *The Normal Helium Atom and the Quantum Theory.* **J. H. Van Vleck.** (Phil. Mag. 44. pp. 842–869, Nov., 1922.)—After a brief critical survey of existing quantum theory models of normal helium, a study is made of the model suggested by E. C. Kemble [Abstract 1680 (1921)] in which the two electrons are arranged with axial symmetry, the one symmetrical type of which the energy had not been computed. As no set of coordinates was found which would separate the variables and thus yield an exact solution in closed form, it was necessary to adopt the standard astronomical method of approximation in which the perturbations are developed as power series in a parameter. The parameter selected was a constant of integration depending on the angle of inclination to each other of the two electron orbits. The analysis, necessarily laborious, was rendered greater than in the case of an astronomical orbit, owing to the relatively large perturbing forces of each electron upon the orbit of the other. It occupied about six months and is reproduced in all essential details. The checking of the accuracy of the calculations by the test of constancy of the energy of the system, commonly used in the astronomical case, would here have involved the extremely laborious calculation of the coefficients of the various periodic terms of the Fourier expansions of the kinetic and potential energies. A much easier method was furnished by the fact that in motion under the inverse square law the average absolute value of the potential energy is twice the average kinetic energy. Since the average value is simply the constant part of the Fourier expansion, and since a power series development is unique, the coefficients of like powers of the parameter must be identical if the computations are correct. There is absolute agreement in the first three terms, while the small errors in the fifth decimal place in later terms are insignificant, and due mostly to neglect of the third and higher powers of the perturbations. The model is a sort of hybid of the Bohr and Langmuir models. It may be approximately described as the projection of a sine curve on a barrel-shaped surface of revolution, the two electrons always being on opposite sides of the barrel. After solution of the dynamical problem the constants of integration were determined by the quantum conditions, and the ionisation potential computed. It was found to be 20·7 volts for the removal of one electron or 74·9 volts for the removal of both. This does not agree with the experimental value of 25·4 ± 0·25 volts [see Abstract 251 (1920)], but the discrepancy is only slightly larger than for the Bohr model, which yields 28·8 volts, the closest agreement for any model based purely on the Sommerfeld quantum conditions. The chemical stability of helium indicates a very simple and symmetrical arrangement of its pair of electrons, but all the models possessing this property now appear to have been tried and found wanting. A reformulation of the quantum conditions is one alternative, and the author considers several of such. But he finds each one precluded by incompatibility with experimental results. A. H. Compton [Abstract 908 (1921)] concludes that the spiral tracks of beta particles indicate the field of an electron not having the spherical symmetry required by Coulomb's law, and he suggests the beta particle acting as a magnetic doublet as well as an electric charge, but if the helium electrons did act as magnetic doublets, the strength of these, to reconcile the calculated ionisation potential of the helium atom model, would be quite incompatible with observed molecular magnetic moments and would invalidate the classical theory of X-ray scattering. Crowther and Schonland [Abstract 1320 (1922)] suggest that some modification of the law of force at *very small distances*, either between two negative electrons or an electron and a nucleus, appears to be demanded by their experiments in the scattering of beta particles. G. W. DE T.

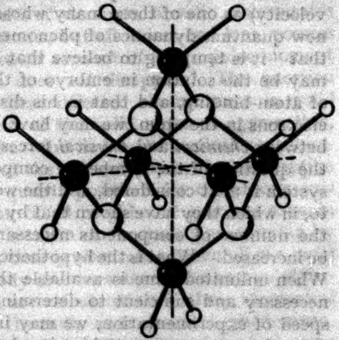
639. *Crystal Structure of Ammonium Chloride.* **R. W. G. Wyckoff.** (Am. J. Sci. 4. pp. 469–475, Dec., 1922.)—Studies of face development, and of etch figures, indicate that NH_4Cl crystals belong to the enantiomorphic, hemihedral (plagihedral) class of cubic symmetry. X-ray powder measurements, and a spectrometic observation, have been interpreted as showing a structure with hemimorphic, hemihedral (tetrahedral), cubic symmetry. The author has studied Laue photographs of this substance, and finds that, if the hydrogen atoms have an arrangement which conforms to the symmetry of the crystal as a whole, this symmetry must be hemimorphic, hemihedral (tetrahedral); if on the other hand the H atoms have a more or less haphazard distribution about the N atoms the crystal symmetry is holohedral. There is only one molecule in the crystal unit. It is suggested that the "latent" symmetry, which is supposed to be made evident by the chemical means of etch figures and growth forms, is probably due not to the symmetry of the crystal itself, but to certain properties inherent in the constituent atoms. The phenomena are of an essentially surface character.

H. N. A.

640. *The Significance of Crystal Structure.* **W. H. Bragg.** (Chem. Soc., J. 121. pp. 2766–2787, Dec., 1922.)—The number of molecules in the crystal cell seems closely related to the symmetry of the crystal and that of the molecule. For example, the molecule of α-naphthol probably has less symmetry than that of naphthalene. The crystals of the two substances, however, have the same symmetry, that of the monoclinic class; but the cells of the first contain four molecules and those of the second only two. The results of Shearer (Phys. Soc., Proc. 35. pp. 81–98; Disc., 98–100, Feb., 1923) are stated by the author as follows: The symmetry of each of the thirty-two classes into which crystals are divided can be attained by the suitable arrangement of a proper number of asymmetric molecules. This number is the symmetry number. The number obtained by dividing the weight of the crystal unit by the molecular weight is either equal to the symmetry number or is a submultiple of it. In the latter case the number obtained by dividing the symmetry number by the number of molecules is the symmetry number of the molecule. Symmetry is arrived at with asymmetrical molecules if they are suitably arranged in pairs. One member of a pair may be the mirror image of the other across a plane of symmetry; or the second may be placed so that it becomes similar to the first, in regard to the mutual orientation of its parts, when it is rotated through two right angles about some axis; two asymmetric molecules may be arranged so that they have a common centre of symmetry. In benzoic acid the existence of double layers parallel to the 001, or cleavage plane, is deduced. The members of the double layer present their carboxyl groups towards one another; but the junction of layer to layer is through the H atoms. The symmetry number of benzene is eight; there are two molecules in the unit and each must have fourfold symmetry. The conventional hexagon does not represent the molecule in the crystal, and a form is suggested for the ring, derived from the arrangement of groups of six carbon atoms in the diamond. Tartaric acid has two-fold symmetry, one molecule being the digonal of the other. In Al_2O_3 it is suggested that the symmetry of the molecule is due to the arrangement of the electrons in the O atoms, the result being a molecule with a digonal axis. Quartz with sixfold symmetry, corundum with twelvefold symmetry, resorcinol, naphthalene, and anthracene are also discussed. H. N. A.

641. *Additivity of the Critical Volume as a Quantum Function.* **G. M. Schwab.** (Zeits. f. Physik, 11. 3. pp. 188–196, 1922.)—The molecular volume depends upon the atomic volume and the atomic grouping, an additive and a constitutive factor. Carbonyl-oxygen has not the same atomic volume as ether-oxygen; that the volume of the hydrogen molecule deviates strongly from Kopp's law can, however, hardly be connected with its constitution. Kopp had based his additive law of 1855 upon the volumes at boiling-point of similar organic compounds; according to the theorem of corresponding states this b.p. volume is a certain submultiple of the critical volume, and the latter is a constant multiple of the true molecular volume; but for substances of low b.p. this latter ratio differs considerably from the normal. The author hence re-calculates the critical atomic volumes ψ_0 of C, O═, —O—, H, Cl, etc., from the b.p. volumes which Horstmann had empirically deduced from about 25 organic compounds. He finds the ratio, critical volume/b.p. volume, approximately equal to 2·665, and he proposes to substitute for Kopp's rule additivity of the critical volume ϕ_0, such that $\Sigma\psi_0/\phi_0 = 1$. For substances of low b.p., $\Sigma\psi_0/\phi_0$ is less than 1. That would indicate that for substances of low b.p. the molecular volume cannot be equal to the sum of the atomic volumes, if we adhere to the rule of corresponding states and hence assume that the critical volume should, for all substances, be the same in multiple of the true molecular volume. But we know that this assumption cannot be maintained for substances of low b.p. In his quantum theorem of corresponding states, A. Byk [Abstract 950 (1922)] has explained his anomaly by the aid of his "reduced effective quantum w." The author shows that the ratio $\Sigma\psi_0/\phi_0$ can be calculated, for all substances, as a function of *w*, *i.e.* as a function of the critical volume, the critical temperature, and the molecular weight. Plotting this ratio for a large number of substances as ordinate against the $1/w$ as abscissa, he obtains a curve which rapidly rises, asymptotically approaching the ordinate value 1. In the case of compounds like HCl, HBr, HI, COS, CS_2, for which the calculated ratio is decidedly greater than the observed, constitutive influences are suggested. H. B.

642. *Crystal Structure of Hexamethylene-Tetramine.* **R. G. Dickinson and A. L. Raymond.** (Am. Chem. Soc., J. 45. pp. 22–29, Jan., 1923.)—X-ray spectral photographs and Laue photographs of $C_6H_{12}N_4$ crystals were taken; this being one of the few known organic compounds, without salt character, which have cubic symmetry; with the idea that better results could be obtained than with crystals of other systems. The observations show that it is probable that each crystal unit contains two molecules. It is assumed that the structure is built up of like $C_6H_{12}N_4$ molecules, present as such, each atom in any one molecule having an atom equivalent to it in every other molecule under the operations of some cubic space group. It is assumed that the relative reflecting powers of the carbon and nitrogen atoms are proportional to the atomic numbers 6 and 7; and a structure is proposed for the molecules, and for their combination into a crystal, which accounts for the observed intensity relations for reflections from different planes. The H atoms were neglected in the calculations, but their probable positions in the molecule are indicated in the diagram. The plane containing a pair of H atoms and the C atom to which they are attached is, in each case, at right angles to the plane containing the C atom and the two N atoms to which it is attached. Such molecules are situated at each corner, and at the centre, of the cubical crystal element; the axes shown by dotted lines in the figure being parallel to the edges of the cube. The crystals should be assigned to the tetratohedral or the tetrahedral class, probably the latter. The only previous information concerning the symmetry class has indicated holohedry. Further crystallographic work, including an attempt to detect pyro- or piezoelectric properties would be of interest. The edge of the body centred cubic lattice is 7·02 Å.; two N atoms are at a distance of about 1·44 Å. from each C atom, and at least approximately in the directions of two vertices of a tetrahedron, in agreement with the prevailing view of the tetrahedral nature of the carbon atom. The H atoms are shown on the directions of the other two vertices of the tetrahedron. H. N. A.



643. *Molecular Dynamics. II and III.* **B. A. M. Cavanagh.** (Phil. Mag. 44. pp. 226–247, July, and pp. 610–640, Sept., 1922.)—Thermodynamics, as such, takes no cognisance of molecules, and it was suggested in

Part I [Abstract 1659 (1922)] that in molecular thermodynamics the terms *molecule* and *chemical compound* should imply, as a rider, Planck's contention: "That the numbers of the various molecular species *can* be considered, together with t and p, as the independent variables determining the phase," so that it *shall* be theoretically sound to conceive any desired change of t and p of the system as taking place without change in the numbers present of the molecular species. Only so can the "mass-action" equilibrium law hold in sufficiently dilute solutions. The misconceptions which have so long prevented a satisfactory theory of electrolytic solution show the need of such a postulate. Moreover, the non-dependence of dissociation (t = constant) on collision frequency shows the inadequacy of the classical concept of a molecule, and suggests discontinuity in the forces maintaining it. Boltzmann, to explain "mass-action" dynamically, had to assume discontinuity in the field of force. A pair of ions, closely linked by the electrostatic fields alone has been regarded as a molecule, and expected to so behave thermodynamically. But from the author's standpoint such forces can form transitory associations only—episodes in the thermal motion—essentially different from molecules. He uses the term *chemical forces* for the means by which a molecule is formed or *bound*, and he argues that the characteristic of these forces, "which appears to be reduced to its lowest terms in the expression *discontinuity of action*," seems to mark out the problem of molecule formation (including reaction velocity) as one of those many whose solution may be hoped for from the new quantum dynamics of phenomena on the atomic scale, and observes that "it is tempting to believe that Bohr's conception of electron-binding may be the solution in embryo of the larger and more complex problem of atom-binding, and that in his distinction between *bound* and *unbound* electrons in the atom, we may have, in its simplest aspect, the distinction between *chemical* and *physical* forces." The entry of the time factor into the question of the number of components required to determine a given system is next considered, and the work of A. Smith and A. Smits referred to, in which they have shown that by increasing the rate of experimentation the number of components necessary to determine certain systems can be increased. What is the hypothetically possible extent of such variation? When unlimited time is available the elementary atomic species will be necessary and sufficient to determine any given system. Increasing the speed of experimentation, we may imagine one complex after another of these elementary atoms taking its place in the list of necessary components. But the masses of the components, with t and p, are the independent variables, so that there may be a limit, since it must be hypothetically possible to alter t and p so quickly that the numbers of these complexes present remain sensibly unaltered during the change. According to the view here suggested, it involves us in a definite postulate bearing on the nature of molecules and of chemical change when we say that the limit is reached when, and only when, every molecular species which can be formed in the system has taken its place in the list of components. Proceeding hypothetically to this limit, we obtain the general expression for ψ, which the author calls "the molecular expression for ψ, and as Planck has shown, it can be determined completely when it is linear by connecting-up with the known properties of the low-pressure gaseous mixture, and when the expression is not linear the terms are subject to a single limitation only, which is inherent in Planck's method. The theoretical problem then presents itself of connecting the experimental expression for ψ, in a trustworthy and practically effective manner, with the molecular expression. Two problems, *complex solvents* and *solvation of solutes*, have been selected for reasons given, and are dealt with in the lengthy analysis, the main result of which is to show that the experimental expression for ψ ultimately assumes the simple form $\psi/M_0 = \phi + R\Sigma c_s(1 - \log c_s) + J + G$. If J and G be neglected, we have the equivalent to van't Hoff's limiting laws of dilute solution, the older criterion of " perfect behaviour." In the circumstances here considered, C and c_s are experimental, *i.e.* directly determinable, quantities, and to the experimenter, J and G will appear together simply as the measurable departure J + G from " perfect behaviour." In terms of the *activity coefficient* γ of G. N. Lewis, and the osmotic coefficient $(1 - \phi)$ of Brönsted, $\log \gamma = -(J_s + G_s)/R$, and $\bar{\phi} - 1 = (J_M + G_M)/RC$, where $\bar{\phi}$ is a mean quantity for the whole solution, characteristic, therefore, of the given solutes, mixed in given proportions. If, as now usual, " perfect behaviour " be defined by the linearity of the full molecular expression for ϕ, the departure therefrom is simply G.

G. W. de T.

644. *The Rotation of Atomic Axes in Solid Bodies (with Magnetic, Thermal, and Chemical Relations).* **W. Schottky.** (Phys. Zeits. 23. pp. 448–455, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag, Leipzig, Sept., 1922.)—The assumption of Bohr with respect to the character of the innermost electronic orbits of elements, if valid, necessitates that not only the known magnetic atoms, but all atoms and ions, possess axes, and that these are directed ones on account of the impulse moment of separate electronic groups which does not disappear. The question of the orientation possibilities of these directed atomic axes in solid bodies is therefore a general problem of the solid state of aggregation, which involves not only magnetic, but thermal and chemical considerations. This problem is the subject of the present paper, the assumption being made that the multiplicity of quanta positions for the atomic axis is not greater for a given orientation of all neighbouring atoms than in the free state, and the simplest case is taken of two positions differing by 180° from each other. The simplest case is also taken when all the axial directions for the atoms of a solid body are the same. The energy differences for the several states assumed are calculated, and these theoretical results then applied to magnetic, thermal, and chemical phenomena. The directive rotatory effect is found in general to be of a very pronounced character. The ferromagnetic transition point is discussed together with the Weiss experiments, wherein for sufficiently strong fields magnetisation in any desired direction may be realised. An explanation is given of the fact that only a small number of paramagnetic substances, *i.e.* those with magnetic atoms or molecules, are ferromagnetic at low temperatures, or exhibit spontaneous magnetisation, as also for the pure paramagnetism of iron compounds. The anomalous specific heats of certain ferromagnetic substances are dealt with, and data given for Na, K, Mg, and Ca. The relationship between certain thermal and magnetic effects is also examined. The final section deals with the vapour-pressure constants of pure substances. For monatomic gases two groups are discussed, *viz.* Ar, Hg, Zn and Cd, and Na, K, I and Br.

H. H. Ho.

LIGHT.

645. *Refraction, Emission Theory of Light, and Quantum Hypotheses.* **F. Kottler.** (Akad. Wiss. Wien, Ber. 129. 2a. pp. 3–26, 1920.)—The origins of a modern emission theory of light; quantum hypotheses and the ether; quanta of energy; Stark's quantum and the impulse law; quanta and interference and refraction; Marx's dual theory, waves with points of concentration; Bohr's rotator; Bohr's rotator and the Maxwell equations; Einstein's quantum theory of radiation; Marx's theory and Bohr's rotator; Marx's waves and the ether; investigation of Marx's waves; refraction by a black screen; the same, reduced to a boundary effect; the refracted wave consists of Marx waves; deductions for a radiation theory. On the whole the well-known equations hold good subject to a wider interpretation. There are qualitative analogies between the action of a refracting surface and that of an atom absorbing and radiating energy. The Maxwell equations are in harmony with quantum concepts, provided we find singular solutions for them. A. D.

646. *Changes in Aberrations when the Object and Stop are Moved.* **T. Smith.** (Optical Soc., Trans. 23. pp. 311–322, 1921–1922.)—If the aberrations of any centred optical system are known both for an object which intersects all rays transmitted by the system and also for the centre of the effective stop, the position in the image space of the emergent portion of a given incident ray is known, and the aberrations in the image of any other object for any stop position can be expressed in terms of those for the first object. The investigation aims to express the relations in the second case in terms of those present in the first when the objects are planes normal to the axis of symmetry whatever the order of the aberration may be.

The investigation is based upon a convenient potential function, and the Eikonal, with the principal foci as reference points, is chosen as the standard function. First a distinction is drawn between aberrational and non-aberrational terms, and the discussion leads to the general form taken by the sine-condition in the outer parts of the field of view; it also becomes evident that there is only one stop aberration of each order to be considered, and that this is of spherical aberration form. The transformation is achieved by a change of variables, and to secure simple forms the aberrations of any order are arranged in series, each series forming a separate group as regards transformations.

The formulæ obtained enable the aberrations to be expressed in terms of the coefficients of the standard Eikonal or *vice versa*, or alternatively the aberrations for any object and stop positions to be given in terms of those for standard positions. For use in the latter case certain advantages are secured by choosing for the stop the position where the magnification is + 1 and for the object the surface for which the magnification is − 1. AUTHOR.

647. *Homographic Treatment of the Symmetrical Optical Instrument.* **G. Temple.** (Phys. Soc., Proc. 35. pp. 30–31; Disc., 32, Dec. 1922.)—The author treats the perfect symmetrical optical instrument by the principles of homography depending upon the fact that the condition for stigmatism implies a (1, 1) correspondence between the points, lines, and planes of the object and image spaces. The paper is mathematical, and cannot be usefully abstracted. J. W. T. W.

648. *Micro-Telescope and Super-Microscope.* **F. Davidson.** (Chem. News, 125. pp. 353–355, Dec. 15, 1922. Paper read before Inst. of Mining and Metallurgy, Oct., 1922.)—The micro-telescope consists of a short focus telescope objective, placed in a tube with a series of diaphragms. This forms an image of a distant object in the plane of the stage of an ordinary microscope. The image formed by the objective is magnified by the microscope, and objects are visible from a distance of 6 ft. outwards. The arrangement has the advantage that inaccessible objects can be examined *in situ*: it also has a very great depth of focus. The super-microscope consists of an achromatic lens combination termed a " collector ": this forms an image of a microscope object at the position of the stage of a microscope. By means of this arrangement it is possible to obtain a magnification up to nearly 1000 diameters, and still have sufficient working distance to illuminate the object from above. The author claims that with the super-microscope it is possible to utilise a higher magnification without losing resolving power. J. W. T. W.

649. *Precision Goniometry of Prisms.* **J. Guild.** (Optical Soc., Trans. 23. pp. 297–310, 1921–1922.)—The author describes the methods used at the National Physical Laboratory for the measurement of prism angles to an accuracy of the order of 1 second. The basis of the method is measurement by substitution, the prism under examination being compared with one of a set of standard prisms by means of a comparator of which a detailed description is given in the paper. A simple form, suitable for measurement within 1 or 2 seconds, is first described, and the second part of the paper contains details of a more elaborate arrangement with which an accuracy of 0·1 second is attainable if desired. This latter arrangement embodies a method of obtaining very minute variations in the direction of a beam of light emerging from a collimator by placing near the focal plane of the latter a " variable prism " of simple design and construction. J. W. T. W.

650. *Geometrical Optics of Prismatic Dispersion.* **H. Erfle.** (Zeits. f. Physik, 11. 1. pp. 56–70, 1922.)—A further contribution to the subject following on previous work by H. Opitz and the author. The paper is largely mathematical. J. W. T. W.

651. *Refractive Power of Liquids.* **C. Dieterici.** (Ann. d. Physik, 67. 5–8. pp. 337–351, June 29, 1922.)—The refractivity of a substance is indicated by the expressions $(n-1)/d$, or $\dfrac{n^2-1}{n^2+2}\Big/d$, where n is the refractive index and d the density. The first expression is called the Beer-Landolt or Gladstone-Dalesche, the second the Lorenz-Lorentz. The question which of the expressions can be taken for the specific refractivity, or used for the molecular refraction as a material, constant has not been decided. The author discusses the matter in the light of the numerous experiments which have been made at various times on the refractivity of mixtures and solutions. If v is the velocity of light in a ponderable medium, and v_0 the velocity in free ether, the diminution of velocity of light when it enters the heavy medium, $v_0 - v$, may be assumed proportional to the number of collisions which the ray of light undergoes in unit of time in the ponderable medium : the collisions not being mechanical shocks, but the joining up of the primary light motion with the induced vibrations caused in the resonators. The number of these couplings must be the greater the larger the number Z of molecules in the unit of volume. It is thus proportional to the density and to the velocity v of light in the medium, $v_0 - v = \alpha Z v$ or $(v_0 - v)/d = n - 1 = \alpha Z$; where n is the refractive index reduced to a vacuum. The number of molecules Z in unit volume is given by $d = M \cdot Z$, where M is the molecular weight and d the density, so $M(n - 1)/d = \alpha$, the *refractivity* of Landolt. This may be expressed better as $M(n - 1)/d = (n - 1)\phi = \alpha$, in terms of ϕ the apparent molecular volume. For mixtures or solutions of two substances, $n - 1 = \alpha Z_1 + \beta Z_2$ where α and β are the voluminal refractions of the components, Z_1, and Z_2 the number of molecules in the unit of volume of the mixture. There are two fundamental questions : First, are the quantities α and β with mixtures or solutions, constant so far as concerns the density of the liquid, independent of the concentration ? In experiments on mixtures of methyl alcohol and water, and ethyl alcohol and water, the quantity $\gamma = \beta/\alpha$ was found to be surprisingly constant with various percentage solutions of alcohol in water. The value of α was found constant with methyl alcohol and the value calculated from the Beer-Landolt formula was identical with that for pure water. The Lorenz-Lorentz expression gave a continuous defect of about 0·5 per cent. The Beer-Landolt, at least as far as concerns the changes of density which occur with the liquids, gives a fully satisfactory expression of the observations, and in the equation $n - 1 = \alpha W + \beta A$, α and β can be regarded as constant within the limits observed, W and A being the number of molecules of water or of alcohol contained in unit volume. This deduction was confirmed by experiments, using the equation, upon acetone-water, and glycerine-water mixtures.

Consideration of the results of experiments on solutions of salts in water is also given, and in general it appears that change in the structure of the molecule brings with it a change in the voluminal refraction. In all watery mixtures $(n - 1)$ is additive and can be calculated from the volume-refractions of the components. It appears also that mixtures and solutions are not strictly separated from each other, but pass over the one into the other.

From the optical relations of watery mixtures and solutions it may be deduced : (1) With all solutions and mixtures there are formed complex molecular groups which Lenard has described in the theory of solutions. (2) With every reaction, whether formation of hydrate or dissociation, so far as a chemical condition is connected with it, there appear new molecular aggregates with new characteristic refraction-constants.

J. J. S.

652. *Magnetic Rotatory Dispersion.* **R. W. Roberts, J. H. Smith** and **S. S. Richardson.** (Phil. Mag. 44. pp. 912–915, Nov., 1922.)—An examination of the rotation produced by paramagnetic substances in the ultraviolet. The cobalt atom, like the iron atom, is capable of producing a negative rotation, but of smaller numerical value ; but on the low-frequency side of the visible band this disappears, on account of the preponderating positive effect of the negative ion. The nickel atom depresses the positive effect of the negative ion, but does not come to preponderate over it at ultra-violet frequencies. A. D.

653. *Polarisation of the Light Scattered by Hg-Vapour near the Resonance Periodicity.* **Rayleigh.** (Roy. Soc., Proc. 102. pp. 190–196, Nov., 1922.)—When light is scattered by air (*e.g.*, in blue sky) there is no approximation to resonance, and the scattered light approaches, but does not reach, complete polarisation. In contrast with this we have (R. W. Wood) scattering of ultra-violet mercury line λ2536 by mercury vapour in resonance with the source. The author wished to trace the transition and obtained some results (incomplete). From these, white light scattered at right angles by dense mercury vapour is, to a first approximation, completely polarised: ultra-violet radiation λ2536, when examined immediately it enters Hg-vapour in an exhausted vessel at room temperature, gives a scattered radiation which is slightly, though definitely, polarised; this polarisation increases as the beam is filtered by penetration of a considerable depth of vapour. After penetration of 27·5 cm. of vapour the weaker polarised image had 60 per cent. only of the intensity of the stronger one instead of 90 per cent. as at first; the radiation removed by the filtration appears to lie within a spectral range of about 1/100 Ångström. A. D.

654. *Polarisation of Light by Single Submicroscopic Particles of Dimensions* 10^{-5} *cm.* **M. A. Schirmann.** (Phys. Zeits. 23. pp. 441–443; Disc., 443–444, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag, Leipzig, Sept., 1922.)—For subjecting the polarisation of light by submicroscopic particles to exact analysis, it has not sufficed to investigate the Tyndall effect for disperse systems as compared with that for colloids of corresponding surface dimensions. This has been due to the average character of the colloidal data. In the method proposed a separate particle is observed in a small plate condenser by means of a suitably imposed electric field. Previously, work on these lines had been suggested by the author [see Abstract 1502 (1919)]. The method employed is based on the polychroic effect afforded by the particles for different modes of illumination, by which the form of the particle may be deduced, since the depolarisation measurements stand in a definite relationship to this; *e.g.*, for spherical particles whose dimensions are comparable with the wave-length of light, the depolarisation is, according to Mie, a function of the spherical radius. Experimental arrangements are briefly described. The following materials were investigated: Au, Ag, Cu, Hg, Pb, Zn, Bi, S, Se, Te, I, glycerine, paraffin oil, and solid paraffin. Symmetrical particles were found for Hg, liquid oils, Au, Ag, Cu, Pb, and for one modification of S, Se, and probably Te; unsymmetrical for I, Sn, Bi, solid paraffin, and certain modifications of S, Se, and Te. The phenomena observed are criticised at length, while a long discussion follows the paper which contains many references to previous work and ideas on this very difficult subject. H. H. Ho.

655. *Propagation of a Fan-shaped Group of Waves in a Dispersing Medium.* **G. Breit.** (Phil. Mag. 44. pp. 1149–1152, Dec., 1922.)—General proof of Gibbs's proposition (Coll. Works, ii, 253) that the image of a fan-shaped group first passed through a dispersing medium and then through a lens does not experience a displacement on account of the dispersing action of the medium. A. D.

656. *Anomalous Dispersion in Vapours.* **M. Maggini.** (N. Cimento, 24. pp. 181–201, Oct.–Nov.–Dec., 1922.)—A study of triplets in the vapours of Mg, Ca, Zn, Cd. The intensity of anomalous dispersion diminishes from the least to the most refrangible component. The coefficients in Sellmeier's formula present values characterisitc of each triplet under varying circumstances; and the coefficient a_2 is a mean proportional between a_1 and a_3; $a_1/a_2=a_2/a_3=k$. Then the at. wt. $P=87\cdot 52/(5\cdot 79-k)$. A triplet may be regarded as a coalescence of two doublets; and the field appears to be open for extension to the case of non-coalescing double lines. A. D.

657. *Geometrical Proof for the Wadsworth Constant Deviation System.* **R. C. Gibbs** and **J. R. Collins.** (Astrophys. J. 56. pp. 483–485, Dec., 1922. Paper read before the Am. Phys. Soc., Dec., 1921.)—This constant deviation system consists of a combination of a triangular prism with a plane mirror mounted on the same rotating table. If a parallel beam of white light is incident upon the prism so that some colour passes through the prism at minimum deviation and is reflected by the mirror, then, as the prism and mirror are rotated together about any axis that is perpendicular to the principal plane of the prism and to the path of the incident beam, the path of the emergent beam for whatever colour is passing through at minimum deviation remains fixed in direction. In order that there may be no lateral shift of the emergent ray, the system should be rotated about the intersection of the plane of the mirror and the plane bisecting the angle of the prism, as an axis. A geometrical proof of the location of the axis is presented which is much shorter than the analytical one given by Wadsworth. J. W. T. W.

658. *Scattering of Light by Spherical Media; Investigation of the Emergent Beam after the Second Internal Reflection.* **J. Rosenberg.** (Ann. d. Physik, 68. 5. pp. 414–440, Aug. 31, 1922. Abstract of Dissertation, Leipzig.)—A theory is developed for the second order beam emerging from a small spherical medium. The theoretical points are applied to the cases of spherical drops of water ranging from 1/3 to 8 wave-lengths in diameter. A. B. W.

659. *Small High-Intensity Mercury Arc in Quartz-Glass.* **L. J. Buttolph.** (Optical Soc. America, J. and Rev. Sci. Inst. 6. pp. 1066–1071, Dec., 1922.)—Description of a small mercury-arc lamp convenient for use in the laboratory. It operates on 110 volts alternating or direct, either as a low-pressure or high-pressure arc. The lamp has an effective light area of 1¾ × ½ inch, and emits little radiant heat. Examples of transmission curves are given for various filters. G. E. A.

660. *The Evaluation of the Colours of the Spectrum in Terms of the Three Primary Colours.* **R. A. Houstoun** and **E. Dow.** (Phil. Mag. 45. 2. pp. 169–176, Jan., 1923.)—If we take three colours, a red, a green, and a blue, and represent them by the corners of an equilateral triangle, then any colour whatever can be represented by a point in the plane of the triangle. The position of the colours of the spectrum on this diagram has been determined by Maxwell, by König and Dieterici, and by Abney, and the results of these observers have obtained considerable publicity. They are, however, not in good agreement. The present paper describes a re-investigation of the subject by a new and simple method and gives a set of results for a normal eye. In the opinion of the authors, through previous work on the subject, sufficient attention has not been called to the variation in the performance of the same eye from day to day. AUTHOR.

661. *Colour-Vision Theories and Colour-Blindness.* **F. W. Edridge-Green.** (Phil. Mag. 44. pp. 916–920, Nov., 1922.)—The facts of colour-blindness are quite inconsistent with any three-sensation theory. Discussion of particular examples. Apparently colour-blindness indicates a less advanced stage of development of the colour-perceiving retino-cerebral apparatus, which is only able to perceive a smaller number of distinct colours. A. D.

662. *An Investigation of the Colour Vision of 527 Students by the Rayleigh Test.* **R. A. Houstoun.** (Roy. Soc., Proc. 102. pp. 353–360, Dec. 1, 1922.)—Lord Rayleigh discovered in 1881 that if homogeneous yellow is matched with a mixture of homogeneous red and homogeneous green, some persons require much more red, others much more green in the mixture than the normal. Such persons have been called anomalous trichromats. The present paper describes a survey made with an apparatus similar to Rayleigh's and embracing a much greater number of observers. The results are exhibited in the form of frequency curves. In the case of 104 women the frequency curve is almost a perfect case of normal variation; in the case of the men the normal curve is there, and outside it lie the colour blind and the anomalous trichromats. But the latter are much fewer in number than would be expected from Rayleigh's original paper. AUTHOR.

663. *v. Helmholtz's Three-Colour Scheme.* **F. Exner.** (Akad. Wiss. Wien, Ber. 129. 2a. pp. 27–46, 1920.)—A. König's three-colour curves were arbitrarily made equal in area, and they do not add up so as to reproduce the spectrum liminosity curve. The author works as follows: Ascertain for the three pigments the saturation-luminosity, avoiding heterochromatic photometry; by the colour-disc ascertain the relative values of the saturation-luminosities in respect to white. These were found to be in the ratio Red : Green : Blue : : 1·000 : 0·756 : 0·024. Multiply König's curves by these factors and now the curves add up so as to reproduce the luminosity curve of sunlight. A slight discrepancy at the violet end indicates an error in one of the König curves which König had himself pointed out. A. D.

664. *Colours of Tempered Steel and other Tarnished Metal Surfaces.* **B. N. Chuckerbutti.** (Indian Assoc. for Cultivation of Science, Proc. 7. 3 and 4. pp. 75–105, 1922.)—The explanation usually put forward for colours of metal surfaces is that they are due to the interference of the light reflected at the surfaces of a thin film formed upon the metal as the result of oxidation. Recently, Mallock [see Abstract 1153 (1918)] has questioned the correctness of this familiar view, since, on trying to polish gently a tempered steel surface, he found no change in the colours observed as the film was gradually removed, and therefore concluded that these colours must be due to some form of selective opacity depending on damped molecular periods comparable with the wave-period rather than on a structure comparable with the wave-length. Beilby considers the film to be an aggregate in open formation, through which oxygen molecules can penetrate to the metallic surface beneath; and the colour formed to depend not only on the temperature to which the metal is raised but also on the time of heating. In the present paper an attempt has been made to explain the colours exhibited by tempered steel and other tarnished metal surfaces; the diffraction of light by the granular film of oxide formed during tempering playing the main part in the theory on the lines first suggested by C. V. Raman.

Experiments made with differently heated plates of different metals supply strong evidence that the colours are due to the granules. The experiments carried out consisted in: (1) Observation and study of the reflected light as the angles of observation are changed, and also of the scattered light in general. (2) Study in detail of the scattered light for various angles between $\theta = 0$ and 180° with quite a large angle of incidence. Curves are included showing the intensity relations of the vertical and horizontal components in the scattered light. The physical theory of scattering as developed by Love and Rayleigh has been employed with slight modifications for conducting particles after the manner of Talbot-Paris, for deriving the theoretical intensity curves. These were drawn employing different values for the sizes of the scattering particles as determined by the microscopic study of the structure formed upon the metal plates. Excellent agreement was found between the experimental and theoretical curves. The author concludes that the scattering of light by the surface structure is an essential part of the colour phenomena. The theory is also claimed to explain in a general way the recorded facts connected with the problem. H. H. Ho.

665. *Photography: The Schwarzschild Constant.* **R. A. Mallet.** (Phil. Mag. 44. pp. 904–912, Nov., 1922.)—By a wedge-screen method not depending on visual comparison of varying shades of blackness, this constant (*i.e.* p in $S = kIt^p$) was found to retain the same value (0·846 to 0·865) for different sensitivities and for varying values of the intensity I and the exposure-time t within normal ranges from the threshold upwards, but excluding solarisation exposures. A. D.

666. *Quantum Theory of Photographic Exposure.* **L. Silberstein** and **A. P. H. Trivelli.** (Eastman Kodak Co. Research Lab. Comm. No. 149. Phil. Mag. 44. pp. 956–968, Nov., 1922.)—Sequel to Abstract 2270 (1922). Discussion of Svedberg and Andersson [Abstract 868 (1922)] and Svedberg [see Abstract 1586 (1922)]. Experimental defence of the position that clumps or aggregates of grains act as photographic units; possibly required modification that the clump must be hit at not less than a certain small distance from its margin. Suggestions for further experiments, which are being carried out. A. D.

667. *Quantity of Light Energy Required to Render Developable a Grain of Silver Bromide.* **P. S. Helmick.** (Optical Soc. America, J. and Rev. Sci. Inst. 6. pp. 998–1015, Dec., 1922.)—The work of previous investigators is first considered. That of Kinoshita shows that each silver bromide grain is rendered capable of development when struck by an alpha-particle from radium C, and that the reduction of developable grains cannot extend to neighbouring un-ionised grains. As the kinetic energy possessed by an alpha-particle of Radium C is $1 \cdot 31 \times 10^{-5}$ ergs, this value gives a max. limit to the energy per grain necessary to form a developable image [see also Abstract 868 (1922)]. Einstein's photochemical equivalence law requires the absorption of a mean energy of effective radiation $h\nu$ for the photochemical decomposition of a molecule. The work of Henri and Wurmser, Leimbach, Nutting, O. H. Smith, Eggert, and Noddack in this connection is also briefly discussed. In the present paper an attempt is first made to predict a natural frequency of silver bromide for the ultra-violet by calculating the ultra-violet max. of the selective photoelectric effect. It appears that the critical frequency of silver bromide corresponds to a wave-length of about $0 \cdot 190\,\mu$. Some of the existing experimental work indicates that this value is of the right order of magnitude. The work of Schumann fixes the corresponding wave-length at about $0 \cdot 210\,\mu$, but the work of Mees indicates a greater value. The other points dealt with are experimental determination of energy required to blacken a grain of silver bromide, the light source, energy measurement, use and construction of absorbing screens, development apparatus, and micro-projection. A table of the results obtained is given. If it be assumed that equal light energies give equal blackenings, then the number of quanta per grain should be the same, no matter whether the flux of light energy be great or small. If the number of quanta per grain be averaged over all the experiments, it is found that about $2 \cdot 3 \times 10^{-7}$ quanta of incident light of mean wave-length $0 \cdot 549\,\mu$ are necessary to render developable a grain of silver bromide. A. E. G.

668. *New Experiments on Photophorescence.* **J. Mattauch.** (Phys. Zeits. 23. pp. 444–447; Disc., 447–448, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—Ehrenhaft [see Abstract 312 (1922)] has designated by photophorescence the discovery by him of the mobile effect which a concentrated beam of light exerts upon small test substances, this being positive when in the direction of the light ray and negative when opposed. According to the Maxwell theory only a positive movement can be expected as a consequence of light pressure. Ehrenhaft distinguishes forces of the first order which light directly exerts on test bodies, and of the second order which involve the surrounding medium, *e.g.*, radiometer forces. Previous experiments by Ehrenhaft and by Parankiewicz [see Abstract 425 (1919)] with different gases and varying pressures had shown the surrounding gas to have no influence. The work of Rubinowicz and of Laski and Zerner on the dimensions of the radiometer forces on spheres is referred to, and the present author now describes more exact measurements of the photophorescent force. The experimental results for test samples of Se show the existence of two different modifications, of which one exhibits the special red colour of Se and the orange, yellow, green, and blue diffraction colours, while both positive and negative test samples occur, which, however, are sharply distinguishable by their dimensions, *viz.*: All with a radius above 17.10^{-6} cm. are positive, and all under to 10.10^{-6} cm. are negative. The positive to light force increases indefinitely with the radius. The other modification exhibits a brilliant white colour, and only unsatisfactory diffraction, while the fall velocity is generally not constant as with the first modification, but linearly decreases with the time. The test samples of this modification evaporate, and for all dimensions observed are negative to light, although the photophorescent force exhibits a maximum and with larger radii declines in value. This shows clearly that the negative to light force is not proportional to the surface as is the light pressure, and unlike the positive force does not increase with the radius. The negative to light force for sulphur exhibits similar characteristics. Te also gives analogous results to Se with respect to its modifications. Ehrenhaft's earlier results are discussed and explained. At high pressures the Laski-Zerner theory (independence of pressure) holds, and at lower pressures that of Rubinowicz (linear decrease with pressure).

H. H. Ho.

669. *Fluorescence of Æsculin.* **J. C. McLellan and [Miss] F. M. Cale.** (Roy. Soc., Proc. 102. pp. 256–268, Dec. 1, 1922.)—In the course of experiments the authors discovered that solutions of æsculin could be rendered non-fluorescent not only by exposure to ultra-violet light, but also by passing through them in darkness ozonised oxygen. In addition, the transformed solutions possessed an absorption spectrum different from that of the original solutions, and the fluorescent power could not be restored by the addition of an alkali, such as potassium hydroxide. Solutions of æsculin freed from air and sealed up in evacuated glass tubes could be made to fluoresce by exposure to ultra-violet light without losing to any measurable extent their power to fluoresce. Aqueous solutions of æsculin were exposed in glass or quartz test tubes to the light from a powerful quartz mercury-arc lamp, and a Nutting spectrophotometer was used to measure the intensity of the fluorescence. It was found that the intensity of fluorescence of solutions as dilute as 1/10,000,000 could be detected and measured. The results of a series of experiments, illustrated by curves, are given, with air, oxygen and ozone, and carbon dioxide, which were bubbled through the solutions. In the case of ozonised oxygen the destruction of fluorescent power is accompanied by a faint luminescence. When the solutions were in exhausted sealed glass tubes they could be made to fluoresce strongly for hours by violet or ultra-violet light in the range of longer wave-lengths without exhibiting any loss in fluorescent power; but in the case of sealed evacuated quartz tubes this fluorescent power was gradually and irrecoverably destroyed by ultra-violet light of the shorter wave-lengths. [See Abstract 1214 (1919).]

T. C. H.

670. *Phosphorescence of MgS Activated by Rare-Earths.* **E. Tiede** and **A. Schleede.** (Ann. d. Physik, 67. 5–8. pp. 573–580, June 29, 1922.) —Pure magnesium sulphide was prepared by heating pure magnesium sulphate in a closed porcelain tube at 800°–900°, through which passed a current of nitrogen charged with CS_2 vapour. The required rare-earth was added to the sulphate before reduction. Good results were obtained with cerium, didymium, praseodymium, samarium, and gadolinium. Neodymium, erbium, ytterbium, yttrium, lanthanum, thorium, and zirconium gave little phosphorescence, but strong kathodoluminescence. The spectrum of the emitted light consisted of lines or narrow bands on a weak continuous background. This is true also of the spectrum of the kathodoluminescence of the MgS activated by Nd, etc. The positions of the bands in the MgS-Sm preparation, estimated roughly with a direct vision spectroscope, are found to coincide with those found for CaS-Sm.

A. C. M.

671. *Luminescence of Ozone.* **M. Trautz** and **W. Seidel.** (Ann. d. Physik, 67. 5–8. pp. 527–572, June 29, 1922.)—Luminescence was easily observed when ozone was passed through a tube electrically heated to 200°, but it diminished as the purity of the gas was increased, and finally disappeared, in spite of a 5-fold increase in concentration of the ozone. Various gases were then introduced as impurities, but only CO gave any effect. With this gas, no effect was produced in the cold, but heating to 150° caused luminescence, and at 200° it was very marked. The light consisted of a band about 460–560 $\mu\mu$, and was (visually) strongest at 500 $\mu\mu$. The width of this band was apparently independent of the concentration, pressure, temperature, and thickness of the layer observed.

Variation of intensity with composition of the mixture was investigated (*a*) dynamically, and (*b*) statically.

(*a*) Purified oxygen passed through a Siemens ozone-tube into a gas-container, which communicated either with an apparatus for determination of O_3 content or a mixing cylinder (in which the pressure could be regulated) connected to a CO apparatus. From this the mixture entered the observation tube, wound round with a manganin heating wire, and containing a Pt-PtRh thermoelement connected to a millivoltmeter. Intensities were observed with a Rb cell filled with argon, and used with a quadrant electrometer.

(*b*) Apparatus as above, but the observation tube modified and incorporated in the photoelectric cell, and a Wulf's electrometer used with the cell.

All experiments were carried out below 450°, so that heat-radiation should be negligible. It was shown that the light emitted is approximately proportional to the product of the initial concentrations of CO and O_3, but independent of the presence of neutral gases, *e.g.*, N_2 and CO_2; the quantity of light emitted tends to a limiting value as the temperature is increased; and the production of the luminescence is a reaction of the second order.

A. C. M.

672. *Classical Dispersion Theory and the Infra-Red.* **C. Schaefer.** (Ann. d. Physik, 67. 5–8. pp. 407–419, June 29, 1922.)—Simple theory requires that a diatomic gas should have one absorption frequency in the infra-red, etc., while for many common gases there are two. One of these is approximately the octave of the other, and explanations have been based on large amplitudes (asymmetrical vibrations) [see Abstract 1073, (1920), and 228 (1917)]. It would be desirable to establish the existence of higher overtones ($3n$, $4n$), and experiments are in preparation. But the theory should hold also for solids, and preliminary results (due to Thomas) confirm this. *E.g.*, for cœlestin absorption is observed at 9 μ, 4·5 μ, 3 μ, and 2·25 μ.

The remainder of the paper deals with the consequences this asymmetrical vibration introduces into the classical dispersion theory. A simple harmonic wave, $\cos n(t - x/q)$, can no longer be propagated in the medium of asymmetrical oscillators. It is concluded that while both classical and quantum theory are satisfactory as long as free vibrations are considered, forced oscillations (as required by dispersion) decide in favour of quanta.

A. C. M.

673. *The Stimulation and Ionisation Voltage of Helium.* **J. Franck.** (Zeits. f. Physik, 11. 3. pp. 155–160, 1922.)—Lyman has succeeded in obtaining a number of lines of the principal series of normal helium in a vacuum spectrometer (Nature, 110. p. 278, Aug. 26, 1922); but with values for the electron energy which differ throughout by about 0·7 volt from those previously given by Franck and Knipping. The author explains how an error was made by them in correcting for the distribution of electron velocity, contact potentials, etc. In this work, the energy of the electrons was gradually raised, until two successive quantum increments were observed on the galvanometer. It was assumed that the distance of the second increase from the first was equal to the energy of stimulation of the line $0 \cdot 5\ S - 1 \cdot 5\ s$; but it is shown that it is really equal to that of $0 \cdot 5\ S - 1 \cdot 5\ S$. The difference is 0·8 volt, and when the values are corrected by this amount they agree perfectly with those of Lyman. The stimulation and ionisation potentials of various gases have been found with reference to helium, and these must be corrected as above. Helium is a very suitable gas for such comparisons since, being an inert gas, it produces no disturbances, and its quantum increments are higher than the ionisation voltages of the gases to be investigated; also the quantum increments are very characteristic. The following corrected values are given: stimulation voltages N_2, 7·7 and 6·9 (weak); ionisation voltages, H_2, $16 \cdot 4 \pm 0 \cdot 25$ and $29 \cdot 7 \pm 0 \cdot 4$; N_2, $17 \cdot 05 + 0 \cdot 3$, 24·7 (weak), 30·0; HI, 12·7; HBr, 13·3; HCl, 13·7; HCN, 14·8. The ionising voltage of helium, as measured, is 24·6, and as calculated 24·5, corresponding to a line at 502 Å. (calculated).

H. N. A.

674. *Practical Spectrographic Analysis.* **W. F. Meggers, C. C. Kiess,** and **F. J. Stimson.** (Bureau of Standards, Bull. 18. pp. 235–255 [Sci. Papers, No. 444], 1922.)—A method of quantitative analysis which has been developed is based on a measurement of sensitive lines which appear in the spectra of certain alloys. Sparks are passed between poles of the material to be measured, a condenser of at least 0·005 m.f., and a self-inductance being introduced in the circuit. Either a quartz spectrograph or concave grating is used to resolve the spectrum, which is recorded photographically as most of the sensitive lines are in the ultra-violet. The spectrogram thus obtained is measured by a travelling micrometer for determining the wave-length, and a special type of microphotometer has been devised for measuring the intensity of the spectral lines. For quantitative results it is necessary to standardise all the conditions, such as the photographic exposure and the intensity of spark, for which purpose a transformer is better than an induction coil as source of current. So far the work has been limited to alloys in which one element predominates. Graded series of such alloys are prepared; for example, tin containing zinc in the proportions 0·001, 0·01, 0·1, 1·0, and 10 per cent. The partial spectra and the relative intensities of their lines under identical conditions are correlated with the percentage composition of the alloys. The main application which has been made so far with this method is to the testing of platinum for use in temperature and electrical standards.

J. N. P.

675. *Some Significant Relations in the Quantum Theory of Spectra.* **S. Ray.** (Nature, 110. pp. 215–216, Aug. 12, 1922.)

676. *Doppler-Effect and Fine-Structure.* **N. Sen.** (Phys. Zeits. 23. pp. 397–399, Oct. 15–Nov. 1, 1922.)—A mathematical paper, in which the analogy is used between the distribution of intensity in a spectral-line broadened by the Doppler-effect, and the distribution of temperature in a heat-conducting medium after the elapse of a definite time interval. From the given empirically-obtained intensity distribution, the ideal fine-structure components (free of Doppler-effect) are deduced. The process is applied to the measurements of Oldenburg on the structure of Hα [see Abstract 684 (1923)]. A. C. M.

677. *Behaviour of Spectral Lines at the Positive Pole of the Metallic Arc.* **P. W. Merrill.** (Mt. Wilson Observat. Contrib. No. 253. Astrophys. J. 56. pp. 475–482, Dec., 1922.)—*Classification of Arc Lines by Relative Strengthening at the Positive Pole.*—In the Pfund type of arc there is a small well-defined region of luminous vapour just above the point where the core of the arc enters the molten bead which forms the positive electrode, and at the boundary of this region many spectral lines change suddenly in intensity to a greater or less degree. By keeping the core of the arc steady and focusing it on the slit of a 30-ft. Littrow spectrograph, plates were obtained from which it was possible to group about 500 *iron lines* from λ3849 to λ5763 into six classes:—Change imperceptible (0), slight (1), small (2), sufficient to double the intensity (3), great (4), or very great (5). The *relationship to the furnace classification* of King was studied for each group. In general the strengthening at the pole is greater for the high-temperature lines, the average class for King's classes I, II, and III being, respectively, 0·2, 1·0, and 1·9. But the average for classes IV and V is only 1·8, and for the diffuse lines of these classes, only 1·3. Lines of each temperature class are also found in each of the positive-pole classes 0, 1, and 2; hence the correlation is only fair, although probably as close as can be expected with such different modes of excitation. The strengthening of the enhanced lines is very marked (average class being 4), so that positive-pole observations may be useful in distinguishing these lines. The classifications of 180 *cobalt lines* and of some *nickel lines* show the same general relationships as were found for the iron lines. AUTHOR.

678. *"Raies Ultimes" and Spectral Series.* **A. de Gramont.** (Comptes Rendus, 175. pp. 1025–1029, Nov. 27, 1922.)—The author showed in 1910 that "raies ultimes"—the last lines to disappear as the concentration of the element is reduced—may be identified with the first member of the principal series. This is now extended to the spark lines, and to other elements. Mercury is anomalous, the "raie ultime" being λ2536·5. [See Abstracts 321 and 1434 (1910).] A. C. M.

679. *Group-Spectra.* **E. Gehrcke.** (Phys. Zeits. 23. pp. 432–433; Disc., 433, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag, Leipzig, Sept., 1922. From the Reichsanstalt.)—An example is given from a portion of the iron-spectrum between λλ4261 and 4375. Of the 24 lines in this section, 22 fall into three symmetrical groups; the remaining two are part of another group [see Abstract 128 (1922)].

The reasons for the existence of these groups are then analysed: (1) Stark-effect due to the strong internal electric field of the atom; (2) Zeeman-effect of the internal magnetic field; (3) Chance, with so many lines the possibility of symmetrical groupings is great. Investigation of the Zeeman- and Stark-effects on the lines of a group would be interesting, as in a true group the lines should show similarity. Groups have also been found in the secondary spectrum of hydrogen, and will be published in conjunction with *E. Lau.*

Discussion. **Hagenbach.**—Groups were found by Hagenbach and Schuhmacher in the iron spectrum, but the width of each group is far too great to be attributed to the Stark-effect. In Gehrcke's groups, the approximation to symmetry is not sufficiently close to show whether wave-length differences or frequency differences are involved. Hagenbach's groups can be represented by a formula involving frequencies. **Glaser** finds similar groups in the spectra of the rare-earths, and molybdenum, tungsten, and chromium. A. C. M.

680. *Absorption of $\lambda 5460{\cdot}97$ Å. by Luminous Mercury Vapour.* **J. C. McLennan, D. S. Ainslie,** and **[Miss] F. M. Cale.** (Roy. Soc., Proc. 102. pp. 33–45, Oct. 2, 1922.)—When the radiation constituting the green line of mercury is passed through moderately luminous mercury vapour, the main component and the components *no.* + 1, $\Delta\lambda = 0{\cdot}0086$ Å., and *no.* − 1, $\Delta\lambda = -0{\cdot}0087$ Å. can be strongly absorbed; no marked absorption by luminous mercury vapour was observed in the case of the other nine compounds of the green line. Of the nine members constituting the magnetically resolved green line, the central undisplaced member was the only one that could be markedly absorbed by luminous mercury vapour. Absorption by luminous mercury vapour of the light constituting the green line in the spectrum of mercury affords a means of clearly and easily demonstrating the components of the line with separations $\Delta\lambda = 0{\cdot}0182$ Å. and $\Delta\lambda = -0{\cdot}0210$ Å., *i.e.* satellites *nos.* + 2 and − 2. Reasons given for a view that $\Delta\lambda = 0{\cdot}0182$ Å., $0{\cdot}0086$ Å., 0, $-0{\cdot}0087$ Å., $-0{\cdot}0210$ Å. correspond to isotopes 197, 198, 200, 202, 204. A. D.

681. *Spark Spectrum of Gallium in Air and in Hydrogen.* **E. Klein.** (Astrophys. J. 56. pp. 373–379, Dec., 1922.)—The spark spectrum of gallium, 2177 to 6414 Å., in air and hydrogen, was photographed with the aid of a Littrow type spectrograph, and the wave-lengths of 83 gallium lines, 14 of them questionable, are given to an accuracy of about ± 0·05 Å. Of these, 23 had been measured by Uhler and Tanch and 26 by Saunders, but 48 are new. The spark in hydrogen was tried because the spark in air oxidizes the gallium, and then the spectrum becomes less rich in lines. To eliminate lines due to possible impurities, spark spectra of Cu, Fe, Pb, In, Zn, and Sn were photographed next to the gallium spectrum. AUTHOR.

682. *New Spectra of Water-Vapour, Air, and Hydrogen in the Extreme Ultra-Violet.* **J. J. Hopfield.** (Nature, 110. pp. 732–733, Dec. 2, 1922.)—In the course of an investigation of the Lyman series of hydrogen the author obtained certain interesting results which he now describes. Water vapour in contact with films renders them insensitive to the extreme ultra-violet—new films may be made sensitive for immediate use if they are thoroughly dried. Water vapour gives a spectrum in the ultra-violet extending to $\lambda 900$. It consists of oxygen lines, hydrogen series lines, secondary spectrum of hydrogen, and some bands probably not due to hydrogen. Using wet hydrogen and a long discharge tube, three new members of the Lyman series of hydrogen were found. There are now six lines of that series known. **A. B. W.**

683. *Argon, Iodine, and Nitrogen Spectra in the Electric Field.* **W. Steubing.** (Phys. Zeits. 23. pp. 427–431; Disc., 431–432, Oct. 15–Nov. 1, 1922. Paper read at the Deut. Physikertag, Leipzig, Sept., 1922.)—This work was undertaken to find out the effect of electric fields on band and continuous spectra, and to discover what factors most influence the optical spectra of the elements in the electric field. The band spectrum of nitrogen was chosen as being the simplest, but difficulties were encountered in the feeble intensity in the positive rays, and also through secondary effects increasing the task of interpretation. The method was to photograph the positive ray spectra with and without an applied field. A tube of special design was employed, with electrodes of large external area for cooling. Exposures of 12 hours were made with currents of 20 milliamps. and 6000–7000 volts (electrode potential). The spectrum decreased in intensity when the field was applied, the bands altered, and the distribution of intensity changed. No displacement or resolution of the band-lines could be found in the highest fields employed. Complete suppression of the bands was unattainable, although fields up to 74,000 volts/cm. were used; the stronger members were always visible. Intensity curves for the bands 3914·4 and 4278·4 (due to Deumens and Ornstein) show that a regular diminution of intensity takes place in both bands. That this difference in intensity distribution with and without field was not due to difference in exposure was shown by taking photographs of the same bands with the same applied field, giving different exposures. A complete study of the diminution of intensity with increase of field was not possible owing to the difficulty of long exposure at high field-strengths; particular lines seemed to be affected more than others; the effect was apparently not connected with secondary effects of the field; and so not connected with the waxing and waning of the kathode rays or positive rays and their changes of velocity in the field.

The continuous spectrum of iodine was next investigated, and consequently carbon electrodes had to be used, so that the cooling was much less efficient, and so weaker currents were necessitated. A bluish-violet continuous spectrum is produced, together with a few weak lines. Application of the field is accompanied by decrease in intensity. The continuous spectrum is suppressed; resolution of the lines takes place, and new lines appear. A list is given of the lines and their behaviour.

Negative results were obtained with argon, using fields up to 38,000 volts/cm. **A. C. M.**

684. *Fine-Structure and Zeeman-Effect of H_α.* **O. Oldenburg.** (Ann. d. Physik, 67. 4. pp. 253–277, May 23, 1922.)—According to Sommerfeld each component in the fine-structure of a Balmer line should give normal Zeeman-effect [see Abstract 52 (1917)]. This is investigated for H_α, and the reason is sought for discrepancies in the previous measurements of the separation of the components (without magnetic field). An echelon grating of 33 plates was employed, set up in a metal chamber having double walls through which water was circulated. The spectrum tube was inserted in the bored magnet-poles and arranged parallel to the lines of force so as to have no effect on the current-density. For large currents the tube was cooled by a current of water; experiments were also made in liquid air. Mercury was avoided, as its vapour causes a great decrease in intensity of the hydrogen spectrum. Current was provided by a coil with a rotary break. The strength of the field was measured with a bismuth spiral: for stronger fields it was deduced from the separation of the *s*-components of H_α. Fields up to 18,000 gauss were used, and in the liquid-air experiments up to 3500 gauss. A nicol was placed between the grating and the tube. The sources of error were found to be in the calibration of the grating, and in the measurement of narrow diffuse doublets. The separation of the components of the close doublet H_α was 0·140 Å.U., with a possible error of 0·008. In the measurement of the *p*-components, in weak fields there is little displacement, but a broadening occurs which gives the appearance of approach of the maxima. As the field is increased, the components run together to form one thin line. The Zeeman separation of the *s*-components is normal in weak fields; with them, also, the fine-structure separation disappears as the field-strength increases. Unless these observations can be explained on the basis of change in the relative intensities, it would seem to be a case of the Paschen-Back effect [see Abstracts 419 and 1282 (1913)]. The possibility of an unforeseen Stark-effect is demonstrated; a comparison of the Zeeman-effect in H, He +, and Zn shows that the lines sensitive to the Stark-effect are diffuse in the magnetic field. Against this, however, is the well-known contrast between the narrowing of the H-doublet in the magnetic field and its broadening through large current-density. It is shown that no Stark-effect is to be attributed to the increase in potential drop in the capillary due to the magnetic field, and also none to the heat-motion of the atoms perpendicular to the magnetic field. A. C. M.

685. *Stark-Effect in Strong Electric Fields.* **A. M. Mosharrafa.** (Phil. Mag. 44. pp. 371–373, Aug., 1922.)—Experiments by Takamine and Kokubu [see Abstract 1212 (1919)] have detected a shift of the central line in the S-component of $H\gamma$ in a strong electric field, as predicted in a previous paper of the author's. A correction is made to an integral employed in the previous paper, but it is shown that the conclusions drawn as to symmetry of the components is not invalidated. The photographs obtained show a shift towards the red, as expected, but the agreement is not quantitative. A. C. M.

686. *Non-Radiating Electronic Orbits and Normal Zeeman Triplet.* **B. Chuckerbutti.** (Calcutta Math. Soc., Bull. 12. 4. pp. 221–224, March, 1922.)—On Bohr's assumptions, we have $mv^2/a = F/a^2$. When the magnetic field $\pm H$ is applied

$$\frac{mv^2}{a + da} = \frac{F}{(a + da)^2} \pm Hev$$

where $(a + da)$ is the new radius. Since $v = 2\pi na = 2\pi n_1(a + da)$, where n_1 is the frequency of the electron in the changed orbits; we reach $n_1 - n = \pm He/2\pi m$. The difference of frequencies of radiation corresponding to the two outer orbits of the triplet will be

$$\pm \tfrac{1}{2}\left\{He/2\pi m - (-He/2\pi m)\right\} = \pm He/2\pi m$$

the same as that obtained according to the Lorentz theory in which the restoring force varies as the distance. A. D.

687. *Theory of Ionisation by Swiftly Moving Electrified Particles and Production of Characteristic X-Rays.* **S. Rosseland.** (Phil. Mag. 45. pp. 65–83, Jan., 1923.)—The theory of ionisation by swiftly moving electrical particles is discussed in its relation (1) to the experiments of Millikan and Wilkins on the production of divalent ions in helium by α-rays, (2) to the increase of intensity of characteristic X-rays with increasing voltage, and (3) to the occurrence of certain lines in the X-ray series which are due to multiple ionisation of the inner electronic groups (enhanced lines). It is pointed out that the phenomenon of multiple ionisation of an atom produced by the action of a single particle is directly connected with the dimensions of the different electronic groups. In this manner the dimensions of the electronic orbits in helium are calculated from Millikan's experiment, and found to be of the order predicted by Bohr's theory. It is also shown that experiments on the dependence of intensity of characteristic X-rays on voltage afford a direct means of investigating the number of electrons in the inner electronic groups of the heavier atoms and the dimensions of these groups. In this connection the appearance of X-ray lines originating from doubly ionised atoms is discussed, and it is concluded that these lines are excited by a single impact of an electron on the atom and not by successive impacts.

A. E. G.

688. *Extraordinary Diffraction of X-Rays.* **L. W. McKeehan.** (Optical Soc. America, J. and Rev. Sci. Inst. 6. pp. 989–997, Dec., 1922.) —The term "Extraordinary Diffraction" is proposed for the directed emission of characteristic X-rays from the atoms of a crystal placed in a narrow beam of X-rays containing sufficiently short wave-lengths. On photographs taken for the crystal analysis of iron, nickel, and copper, spots occurred, evidently diffraction images of the source, at places and in positions quite inexplicable by the ordinary theory of X-ray diffraction in crystals. The author develops from fundamental reasoning a theory of atomic diffraction which covers both "ordinary" and "extraordinary" diffraction, but the theory is hardly capable of presentation in an abbreviated form.

B. J. L.

689. *Intensity of Reflection of X-Rays of Different Wave-Lengths in Calc-Spar and Rock-Salt.* **E. Wagner** and **H. Kulenkampff.** (Ann. d. Physik, 68. 5. pp. 369–413, Aug. 31, 1922.)—The authors have determined in absolute measure, by a method of double reflection and using monochromatic X-radiation, the reflection coefficient R for the 100 planes of calc-spar and rock-salt. The variation of R with wave-length $\lambda = 1\cdot39$ to $1\cdot93$ Å.U. has also been investigated. The method employed involved the continuous rotation of the crystals and the intensity of the second reflection measured by an electrometer method. The reflection coefficient of calc-spar was found to be practically independent of the wave-length; in the case of rock-salt the reflection-coefficient decreases with increasing wave-length. On the average, rock-salt reflects about three times as strongly as calc-spar. The ratio of the coefficients of reflection R_2/R_1 for the first and second order (100) of both crystals has been measured for the $k\,.\,\alpha$ lines for copper and iron; the observed values agreeing with theory.

A. B. W.

690. *A Balance Method of Measuring X-Rays.* **S. Russ** and **L. H. Clark.** (Phil. Mag. 44. pp. 1159–1164, Dec., 1922.)—Experimental method, analogous to Rutherford's [Bronson, Abstract No. 307 (1906)]. Necessity for an international unit of X-ray intensity. A. D.

691. *X-Rays.* **E. Fermi.** (N. Cimento, 24. pp. 133-163, Oct.-Nov.-Dec., 1922.)—*Résumé* of the principal phenomena of X-rays and their relations to one another. A. D.

692. *E. Hjalmar's Work concerning the M Series of the Elements.* **A. Dauvillier** and **L. de Broglie.** (Comptes Rendus, 175. pp. 1198-1201, Dec. 11, 1922.)—Hjalmar's recent spectrographic measurements [Abstract 510 (1923)] strikingly confirm the authors' theoretical estimate of the structure of the Röntgen-ray spectra [see Abstract 509 (1923)]. Summarising a critical examination of his results, they conclude that there is apparently no spark line in the M series of the heavy elements and that only the two lines 2673 and 2709 X of uranium escape the combination principle, while the remaining 25 fully bear out their theoretical forecast. E. F.

RADIO-ACTIVITY.

693. *Measurement of Radium Emanation in the Air of Innsbruck.* **R. Zlatarovic.** (Akad. Wiss. Wien, Ber. 129. 2a. pp. 59-66, 1920.)—Instead of first condensing the emanation, by means of liquid air or charcoal, and then introducing it into the measuring vessel, the author, in places where the geological conditions cause the amount of emanation in the air to be large, measures it directly, by observing the effect of the emanation contained in the measuring vessel, and then removing the whole of the emanation by suitable means and repeating the readings. The difference in the two saturation currents is a measure of the emanation originally in the vessel. The activity of the walls of the vessel must be small and constant; and the radiation from outside, which penetrates the vessel, must also be constant. In the Innsbruck Physical Institute this radiation is so constant, that it is not necessary frequently to repeat the observation with emanation free air; but the varying emanation content, from time to time, can be deduced from single readings of the saturation current. Two different methods were employed to remove the emanation from the measuring vessel, absorption with "rademanit," a finely powdered charcoal, and with petroleum. Corrections are necessary for the disintegration of the radium emanation, during the interval between filling the vessel and the first electrometer measurement, and for the fact that all the α-particles do not produce their full effect, the difference depending on the dimensions of the vessel. The mean of 49 observations taken during the summer months gave for the density of the emanation in the air $\rho = 433 \times 10^{-18}$ curies per c.c., the maximum value obtained being 1110×10^{-18}, and the minimum 40×10^{-18} curies per c.c. Rainy weather gave low densities. H. N. A.

694. *The Active Precipitate from Radium in an Electric Field.* **A. Gabler.** (Akad. Wiss. Wien, Ber. 129. 2a. pp. 201-220, 1920.)—A quantitative measurement, using large quantities of emanation. The distribution of radio-active matter in an electric field is influenced (S. Ratner) by an electric wind which always occurs in an ionised gas in an electric field; and this influence was great in the author's experiments. A. D.

695. *Loss of Energy of an α-Ray Beam on Passage through Air or* CO_2. **P. L. Kapitza.** (Roy. Soc., Proc. 102, pp. 48–71, Oct. 2, 1922.)—Energy of an α-particle determined by measuring the heating effect it can produce after having traversed a definite portion of its range. The α-particle has no energy beyond the end of its range as determined by ionisation methods. The α-rays with high velocities expend on an average more energy in the production of an ion than those moving with low velocities; *i.e.* the former drive out a greater proportion of inner electrons. Comparing the energy distribution curve with that obtained by measurement of the velocities of the α-particles by deflection in a magnetic field, the agreement is good up to 6 cm., but beyond that the energy curve gives distinctly smaller values. The heating effect of the β-rays was measured, and the energy-absorption curve in aluminium was determined. The heating produced in CO_2 over different portions of the range was measured, and in this way curves very similar to the ordinary ionisation curves were obtained. A. D.

696. *Blackening of Photographic Plates by α- and β-Rays.* **H. Salbach.** (Zeits. f. Physik, 11. 2. pp. 107–128, 1922. Extract of Dissertation, Berlin.)—Schwarzschild's formula for the blackening S of a photographic plate by light is $S = \phi(I^q t)$, where I is the intensity of illumination; q varies for different kinds of plates, and is not the same for long exposures and small intensities as for short exposures and high intensities, varying for a Schleussner plate between 0·8 and 1·2; when $q = 1$ the law becomes identical with that of Bunsen and Roscoe. In a series of experiments with α-rays, using a Marten's polarisation photometer to measure the blackening of the plates, and a Friedrich and Koch tube photometer checked by measurements with an electroscope to determine the intensity of the α-rays, values of q approximating to unity were obtained with "Agfa," "Schleussner" and "Jahr" plates. The values of q for the same plates with light were 1·23, 1·22, 1·22; and with β-rays 0·81, 0·86, 0·83. Absorption measurements with the β-rays from UX showed that the different plates are not equally affected by β-rays of different hardness. The exponent of the equation of blackening is, however, practically the same for all such rays. H. N. A.

697. *β-Ray Spectra and their Connection with γ-Radiation.* **L. Meitner.** (Zeits. f. Physik, 11. 1. pp. 35–54, 1922.)—Ellis has investigated with β- and γ-rays of RaB + C [Abstract 1782 (1921)], and came to the conclusion that the primary action in the disintegration of RaB is the emission of definite monochromatic γ-rays, owing to the passage of an electron from one energy level in the nucleus to another. He has observed three γ-rays, and assumes the existence of three others; and supposes that the ejected electrons are released from the different extranuclear quantum orbits by the action of these γ-rays. He finds the energy of the electron to be equal to that of the γ-ray which releases it, minus the energy required for its release. The author comes to the conclusion that in all such cases the first thing that happens is that an electron is ejected from the nucleus with definite velocity and energy. In some cases this energy is integrally given up to a γ-ray, while in others the β-ray passes on; it may pass right out of the atom, or it may strike one of the outer electrons and drive it out. Secondary β-rays are also produced by the action of the γ-rays, as stated by Ellis. In ThB the primary β-ray has the energy $3 \cdot 738 \times 10^{-7}$ ergs, practically equal to that of the γ-ray which releases β-rays from the K and L_1 levels. With ThC a β-ray with 95 % of the velocity of light had previously been observed by the author; and regarded by him as primary. Ellis did not find this; and the author himself, using Danysz' method, failed to do so; but did so again with Rutherford's method, which shows rather a broad line at this point. The Danysz method had great resolving power and spread this "band" over so large an area that it was too faint to be seen on the photograph. RaD shows three lines in the β-ray spectrum. One of these is regarded as the primary, one comes from the M level, and the third from the L_2 level. Apparently Ellis' results on RaB indicate that the only β-ray from the L levels is that from L_2. It is suggested that the M and L_2 levels, being nearer to the nucleus than the other levels, are more easily affected by γ-rays from the nucleus. According to Sommerfeld the L_2 orbits are elliptical while the L_1 are circular, so that the former come much nearer to the nucleus than the latter. The continuous β-ray spectrum observed by Chadwick is also discussed, his apparatus is criticised, and it is concluded that there is no primary continuous β-ray spectrum. H. N. A.

698. *Ramifications and Breaks in β-Ray Orbits.* **W. Bothe.** (Phys. Zeits. 23. p. 416, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag, Leipzig, Sept., 1922.)—By the Wilson cloud method a large number of stereoscopic pictures of β-ray orbits have been made, and the following peculiarities noted. Distinct ramifications have been distinguished in 8 of the orbits, and also two branches of the β-ray type, lying perceptibly in a plane with the main orbit and forming according to stereoscopic estimation an angle of almost 90° with one another. The strongly deviated branch was shorter and denser, corresponding to a smaller velocity than the other. These are the relations which are to be expected from an impact of the β-particle with a slowly moving, feebly bound electron. The author points out that a method is here afforded for investigations into electrodynamics of dimensions $< 10^{-11}$ cm. The ray orbits also exhibit sharp breaks due to particles in the immediate vicinity of an atomic nucleus, being deviated through a large angle by this field of force. A difference between α- and β-particles is that a deviated β-particle does not perceptibly lose energy by deviation, whilst an α-particle very quickly does so. The differences between α- and β-particles are due to the much smaller masses of the latter. From 9 of the best ray orbits it was established by probability analysis that no ground exists for the assumption of a continuous orbit curvature. The latter assumption is opined to be due merely to the psychological tendency of regarding a series of consecutive points as a smooth curve. H. H. Ho.

HEAT.

699. *A Problem in Thermometry.* **S. P. Owen.** (Univ. of Durham Proc. 6. 3. pp. 148–159, 1921–1922.)—The temperature indicated by a thermometer in a medium whose temperature is changing presents a lag; find the lag, taking into account the effect of the containing vessel. Complete solutions obtained for (1) surface conductivity infinite, bulb spherical; (2) surface conductivity finite, bulb spherical; (3) surface conductivity infinite, bulb cylindrical; (4) surface conductivity finite, bulb cylindrical. The mean lag in all cases takes a form $\theta - \sum\theta_n \epsilon^{-p e_n^2 t}$ where only the first term of the series has numerical significance. Results plotted out. A. D.

700. *Physical Constants of Ozone.* **E. H. Riesenfeld and G. M. Schwab.** (Zeits. f. Physik, 11. 1. pp. 12–21, 1922.)—Further particulars are given of the melting-point determinations [made with the aid of the copper-constantan couple of Nernst, Koref, and Lindemann, Abstract 821 (1910)] and other determinations (Kuhlmann micro-balance). The density values found fluctuated between 1·6 and 1·82, the average for − 183° C. being 1·71. Critical temperature and expansion are determined in stout glass capillaries within a block of copper; the expansion coefficient 0·0025 would yield a density 1·46 at the boiling-point. The critical density calculated is 0·537. The authors find that Byk's quantum theorem [Abstract 950 (1922)] can well be applied to ozone, though ozone on the whole obeys van der Waals' rule of corresponding states better than oxygen does. The latter circumstance would support the conclusion that ozone does not contain any molecules other than O_3; for substances having different molecules in the liquid and gaseous states should (like water) be anomalous with respect to the van der Waals theorem. H. B.

701. *Boiling-Points of Ammonia, Sulphur Dioxides, and Nitrous Oxide.* **F. W. Bergstrom.** (J. Phys. Chem. 26. pp. 876–894, Dec., 1922.)—The magnitude of errors introduced by using a single-walled vessel in the determination of boiling-points have been determined by the comparison of results so obtained with those given by a vacuum-jacketed vessel. The results show that the boiling-point of ammonia is about 0·2° high when determined in a single-walled vessel, even with the internal application of energy; this error is reduced if a Cottrell tube is used. A vacuum-jacketed vessel should give accurate values of boiling-points down to about − 90° C. if a correction is applied for the depth of immersion of the thermometer bulb and there is no uncooled stem. The lowest temperature at which the Cottrell tube was used was − 33·4°, but with larger boiling vessels and larger Cottrell tubes accurate results should be obtained at much lower temperatures. By using the Cottrell tube the correction for the depth of immersion of the thermometer is eliminated, and better equilibrium between the vapour and liquid is obtained.

The resulting values of the normal boiling-points are: Ammonia, − 33·41° ± 0·1°; sulphur dioxide, − 10·02° ± 0·1°; nitrous oxide, − 89·5° ± 0·2°. A. W. L.

702. *The Vapour Pressures of Solid and Liquid Chlorine and Bromine.* **F. A. Henglein, G. v. Rosenberg,** and **A. Muchlinski.** (Zeits. f. Physik, 11. 1. pp. 1–11, 1922.)—As in the previous experiments, the gases are generated by heating auric chloride and bromide and are led into highly evacuated bulbs (10^{-6} mm. of mercury, Volmer pump) placed in a Dewar vessel which is filled with various cooling agents; sometimes the bulb is immersed in frozen mercury. The temperature of the bath is determined by the vapour-pressure thermometer of Stock and Henning [Abstract 1800 (1921)]. The vapour pressure of chlorine rises from 0·0013 mm. Hg to 0·028, 2·75, 64·4 as the temperature rises from 119·2 to 133, 161 and 194·5° K.; for bromine from 0·002 to 0·26, 6·44 mm. at 177·6, 210, 241° K. Chlorine melts at 170° K. and has then a vapour pressure of 8·9 mm. The properties of solid chlorine are not described; for liquid chlorine the vapour-pressure values found lie between those of McIntosh and of Pellaton. The vapour-pressure curve for solid chlorine is calculated from the dissociation equilibrium and the chemical constant of monatomic chlorine after Stern-Tetrode; the chemical constant of diatomic chlorine is deduced with the aid of A. Langen's formulæ [Abstract 1499 (1920)]. H. B.

703. *Specific Heat of Solids at High Temperatures and the Quantelisation of Oscillations of Finite Amplitude.* **E. Schrödinger.** (Zeits. f. Physik, 11. 3. pp. 170–176, 1922.)—Recently Born and Brody [Abstract 1154 (1922)] have developed a theory of the specific heat of solids at high temperatures, the chief result of which is their conclusion that deviations from Dulong and Petit's law at high temperatures are to a first approximation proportional to the absolute temperature. This result is proved on the quantum theory, and the authors point out that the same result can be obtained on the classical theory, but that it is not simpler [see Abstract 248 (1922)]. The present author disagrees with this latter statement, and gives a mathematical proof based on Hamiltonian functions for a mechanical system. T. B.

704. *A Critical Review of Trouton's Law and its Applicability at the Triple Point.* **S. B. Mali.** (Phil. Mag. 45. pp. 94–97, Jan., 1923.)—According to Trouton's law the ratio of the molecular latent heat of vaporisation of a substance to the temperature of vaporisation is a constant for all substances and this was shown later to be applicable in the case of fusion, and so could be generalised. Nernst demonstrated afterwards that the law does not hold generally, and instead he finds an expression of the type,

$$M\lambda/\theta = A \log \theta - B\theta, \text{ where A and B are constants.}$$

The object of the present paper is to examine critically the validity, and the theoretical foundation, if any, of the Trouton law. The triple point appeared a suitable temperature at which to examine the Trouton quotient, but calculations do not support the generalised view, and it seems to be fairly well established that there is no particular point of temperature at which the Trouton law holds. Neither does the law seem to have any theoretical significance; and the fact that it approximately holds good for a few selected substances when the vaporisation considered is under one atmospheric pressure appears to be purely accidental. H. H. Ho.

705. *Measurement of the Specific Heat C_v of Gases by the Differential Method.* **M. Trautz** and **O. Grosskinsky.** (Ann. d. Physik, 67. 5–8. pp. 462–526, June 29, 1922.)—This is a long and detailed paper describing a method of measuring C_v which was originated by Trautz (see Lehrb. d. Chemie, Vol. II, 1922, p. 36 u. 60). After a brief historical sketch of the different methods which have been used to measure the specific heats of gases, the authors describe in detail their own method. This method has two great advantages, namely, that the gas is made to look after its own loss of heat, and to act as its own thermometer. Essentially it consists in using two large flasks, the " gas flask " and the " measuring flask." These are immersed in a large water bath, and are connected by a manometer. Each flask contains an extremely thin platinum grid, through which an electric current can be sent from the secondary of a transformer. The " measuring flask " is connected with an oil reservoir, so that the volume of the gas (air) in the flask can be altered by removing oil. If the " gas flask " contains air, and a current is sent through the heaters, a cloudlet of hot air is formed in each flask, and this will be surrounded by colder air. The result of this is an increase of pressure, and by withdrawing oil from the " measuring flask " the pressures may be balanced with the help of the manometer. If the air be now removed from the gas flask and another gas introduced, we can repeat the process and balance the pressures as before. The ratio of the molar heats of the two gases in the gas flask are then (neglecting small corrections) proportional to the volumes of the gas in the measuring flask.

In the ideal case in which both flasks are exactly alike and are filled with the same gas, and an equal quantity of heat energy is given to each flask, there will be no corrections for heat lost by conduction or radiation, nor for heat remaining in the heaters. A full description is given of the construction of the different parts of the apparatus, of the method used, and of precautions taken in using the apparatus. The formulæ necessary are obtained and discussed, and finally the results obtained for carbon dioxide are shown to agree amongst themselves to better than one part in a thousand. The values for hydrogen are not in quite such close agreement owing to the flasks not being large enough. The absolute values of the specific heats are in good agreement with the results of other investigators. The whole paper represents the outcome of ten years' work. A useful list of references to papers dealing with the measurement of specific heats of gases is given. T. B.

706. *Theory of the Specific Heat of Liquids.* **K. Honda.** (Phil. Mag. 45. pp. 189–192, Jan., 1923.)—The theory of the specific heat of solids first developed by Einstein [Abstract 439 (1907)] and improved by Nernst [Abstracts 821 (1910) and 1182 (1911)] and others, accords with the observed facts, provided the temperature is not very high; also for gases, provided the temperature is not extremely low. As regards the liquid phase there is as yet no satisfactory theory; the present paper is an attempt to fill this gap. In solid substances, free rotation of the atoms is not possible. Thus each atom of a solid vibrates about its mean position with three degrees of freedom. On raising the temperature of the solid rotational vibrations are also set up, and on approaching the melting-point the amplitude of these vibrations attains such a value that the rotational vibration becomes at last a continuous rotation. The atoms thus set free have now two or three degrees of freedom for rotation. If all the atoms undergo the above change, the fusion is completed, and the crystal changes into a liquid. The total energy of the substance at temperature T above its melting-point T_m is shown to be $W = 3RT_m + \frac{1}{2}nRT + Q + 3R(T - T_m)(1 - e)$ where R is the gas constant $= 1 \cdot 96$, $n = 2$ or 3 (degrees of freedom gained), Q is the energy required for doing work during change of volume in melting and e is between 0 and $\frac{1}{2}$. The atomic heat at constant volume in the liquid phase is then $C_v = dW/dT = 3R(1 - e) + \frac{1}{2}nR$. Also if C_v' be the atomic heat in the solid phase at the melting-point, we have $C_v - C_v' = R(\frac{1}{2}n - 3e)$ which is the change of atomic heat during melting. This difference has a positive or negative value according to the nature of the substance. The above conclusions agree with the facts experimentally found. T. B.

707. *Linear Conduction of Heat through a Series of Connected Rods.* **S. Sakai.** (Tôhoku Univ. Sci., Reports 11. pp. 351–378, Nov., 1922. Sixty-seventh Report, Research Inst. for Iron, Steel, and other Metals. In English.)—The problem of heat conduction through a finite rod consisting of different materials, under a given boundary condition, its temperature being initially zero throughout the rod, has been solved by Carslaw by an ingenious method due to Bromwich [see Abstract 1438 (1920)]. The present problem is an application of Carslaw's method to a more general case, that is to the case of the linear conduction of heat through a finite rod, consisting of n different parts, the temperature at both ends being given, and the initial temperature being everywhere zero. The case is also considered where at the heated end radiation takes place into a medium, the initial temperature of the rod being zero. The case of a variable temperature at the boundary surface is also solved. Finally two special problems in case of no radiation are taken, the first being where n (the number of different parts of the rod) is 2, and the resulting equations being those obtained by Carslaw. The second problem, which is the most important practical application, is that of a thin plate, which is less conductive, being inserted between two rods. As a particular example of the second problem, it is shown that the effect of an air film between contact surfaces of two copper rods will be negligibly small if the air film is sufficiently thin. The paper is entirely mathematical. T. B.

708. *An Optical Study of Free and Forced Convection from Thin Heated Wires in Air.* **S. C. Pramanik.** (Indian Assoc. for Cultivation of Science, Proc. 7. 3 and 4. pp. 115–123, 1922.)—This is an amplification of a paper by B. B. Ray, who studied the form of the isothermals in air round a heated cylinder. An extension is here made to thin wires, of diameters from 0·036 to 0·121 cm. The wires are heated electrically, and changes of density of the air in the region of the wires cause deviations of the rays of light from an arc lamp. Photographs are then taken which give almost an exact picture of the distribution of hot air and its temperature variations as indicated by the luminosity of its various parts. It is found that the wire is completely enveloped by a film of hot air, both in free and in forced convection, this effect being ascribed to the viscosity of the gas. In the immediate neighbourhood of the wire the flow of heat is mainly by conduction; at other parts by convection. The photographs bring out very clearly (1) that there are two streams of hot air from each wire, separated by a "stagnant" space due to the shielding of the wire; (2) the circle of hot gas all round the wire; (3) "attraction" of streams of air by two parallel wires; (4) for a grating of parallel wires the inner streams are annulled, the external ones having an augmented effect; (5) in the case of forced convection, as heat is conducted away more quickly the temperature falls with a consequent diminution in the size of the streams. Some preliminary attempts have also been made at measuring the distribution of temperature around the wire by an interference method. T. B.

709. *Black Radiation and Light Quanta.* **L. de Broglie.** (Comptes Rendus, 175. pp. 811–813, Nov. 6, 1922. J. de Physique et le Radium, 3. pp. 422–428, Nov., 1922.)—The author's aim in both papers is to facilitate the construction of an interference theory in harmony with the existence of light quanta.

First Paper.—The fluctuations of black radiation in volume V of an enclosure in thermal equilibrium are given by the equation $\epsilon^2 = kT^2 dE/dT$, where T is the temperature of the enclosure, k Boltzmann's constant, ϵ the deviation from its mean value E of the instantaneous value of the energy of frequency ν and of the spectrum interval $d\nu$ contained in V. Taking Planck's law

$$E = 8\pi h\nu^3 V d\nu / c^3 (e^{h\nu/kt} - 1), \quad \epsilon^2 = h\nu E + c^3 E^2 / 8\pi\nu^2 d\nu V,$$

as Einstein showed in 1911; and the first and second terms on the right are, respectively, the values of ϵ for the entirely electromagnetic undulatory Rayleigh-Jeans radiation, and the entirely quantised radiation of Wien's law. Now from the viewpoint of light quanta, it seems logical to write Planck's formula

$$E = \sum_1^\infty {}_n \, 8\pi h/c^3 \, . \, \nu^3 e^{-nh\nu/kT} V d\nu = E_1 + E_2 + \dots + E_n + \dots$$

Here E_n represents energy divided into quanta $2h\nu$, so that

$$\epsilon^2 = \sum_1^\infty {}_n \, nh\nu E_n,$$

which corresponds to "gas of light particles" formed of molecules and atoms. That this new form of the formula is identical with Einstein's follows from the easily verifiable identity

$$\sum_2^\infty {}_n (n-1) h\nu E_n = c^3 E^2 / 8\pi\nu^2 d\nu V.$$

It appears, then, that from the light quanta viewpoint, interference phenomena are associated with the existence of agglomerations of "light atoms" whose movements are not independent but coherent, which suggests that if the quantum light theory ever provides an interpretation of interference, it must introduce such agglomerations.

Second Paper.—The author starts with the assumption that black radiation at temperature T consists of a gas formed of atoms, each having energy $W = h\nu$, and therefore a momentum $h\nu/c = W/c$, and the pressure per unit of boundary surface, for n atoms per unit volume, will be $n\mathrm{W}/3$, as in electromagnetic theory and as verified experimentally. Then by statistical mechanics, $dn = \mathrm{C}e^{-\mathrm{W}/k\mathrm{T}}\,dx\,dy\,dz\,dp\,dq\,dr$ (integrating throughout the volume, replacing $dp\,dq\,dr$ by $4\pi\mathrm{G}^2d\mathrm{G}$, where G is the length of the momentum vector, and substituting W/c for G) $= ne^{-\mathrm{W}/k\mathrm{T}}\mathrm{W}^2d\mathrm{W}/2k^3\mathrm{T}^3$. Multiplying by W gives the energy intensity, and taking n a function of T only and integrating, its amount is $3nk\mathrm{T}$, twice that of the same number of gas molecules, an expression of the fact represented electromagnetically by the equality of electric and magnetic energy in a light wave. The energy in volume V will then be $\mathrm{U} = 3nk\mathrm{TV}$. Then if S be the entropy, $d\mathrm{S} = (d\mathrm{U} + pd\mathrm{V})/\mathrm{T}$ must be a perfect differential, the condition for which is $n = \mathrm{A}k^3\mathrm{T}^3$, where A is an integration constant (obviously $\mathrm{A} = \sigma/3k^4$, where σ is Stefan's constant). Substituting $h\nu$ for W in the energy intensity expression, we have $du = \mathrm{A}h^4e^{-h\nu/k\mathrm{T}}\nu^3d\nu/2$, which is in the form of Wien's law. Can the constant factor be determined without use of the experimental σ? The free energy

$$\mathrm{F} = \mathrm{U} - \mathrm{TS} = -n\mathrm{V}k\mathrm{T} = \mathrm{N}k\mathrm{T},$$

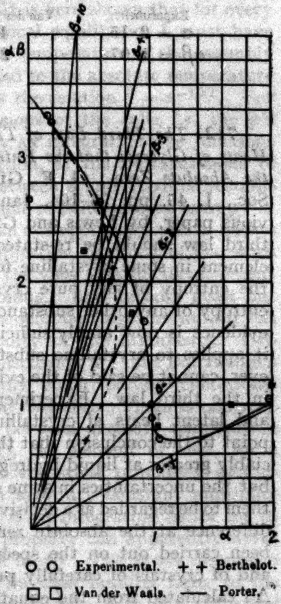
say. There is no additive constant, because $\mathrm{U} - \mathrm{TS} + p\mathrm{V} \equiv 0$, and the rest mass of the atoms is zero. Now Planck [Abstract 354 (1922)] and others, in calculating the *chemical constant*, have assumed a gas NT with Gibbs' canonical distribution, in which $\mathrm{F} = -k\mathrm{T}\log\sum_n e^{-\epsilon_n/k\mathrm{T}}$, the summation being extended to all possible states of the gas. This is expressible by an integral over the 6N-dimensional phase space, and is equivalent, when divided by N!, to the product of N sextuple integrals over the phase space of every molecule, and gives, finally,

$$\mathrm{F} = -k\mathrm{NT}\log 8\pi e\mathrm{V}k^3\mathrm{T}^3/\mathrm{N}h^3c^3.$$

Identifying this value of F with $\mathrm{N}k\mathrm{T}$, as found above, and since also $\mathrm{N} = \mathrm{A}k^3\mathrm{T}^3\mathrm{V}$, we have $\mathrm{A} = 8\pi/c^3h^3$, and hence, $du_\nu = 4\pi he^{-h\nu/k\mathrm{T}}\nu^3d\nu/c^3$, half what it should be. Brillouin has suggested that this may very probably arise from polarisation of light not having found a place in the theory, and that a more complete quantum theory of light should introduce it somewhat in the way of each light atom being associated with an internal state of right or left circular polarisation represented by an axial vector in the direction of its motion and that two atoms otherwise identically similar should be taken as such only if the direction of polarisation were the same in each. This would introduce 2^N under sign *log* in the expression for F, and give a coefficient in exact numerical agreement with Wien's law. G. W. DE T.

710. *Temperature Changes Accompanying Isentropic, Isenergic, and Isenkaumic Expansion.* **L. H. Adams.** (Washington Acad. Sci., J. 12. pp. 407–411, Nov. 4, 1922.)—In isentropic expansion, where the entropy S remains constant, $-(\partial\mathrm{T}/\partial\mathrm{P})_\mathrm{S} = -\alpha\mathrm{T}/\mathrm{C}_p$, where α is the coefficient of expansion $(\partial v/\partial\mathrm{T})_p$. For explosive release of pressure, or isenergic expansion, $-(\partial\mathrm{T}/\partial p)_\mathrm{E} = (\beta p - \alpha\mathrm{T})(c_p - \alpha p)$, β being the compressibility, $(\partial v/\partial p)_\mathrm{T}$. In isenkaumic expansion; when the fluid streams through a porous plug, or throttle, under adiabatic conditions; the quantity H, commonly called the heat content, remains constant. H may also be spoken of as the enkaumy $-(\partial\mathrm{T}/\partial p)_\mathrm{H} = (v - \alpha\mathrm{T})c_p$. If the pressure on a solid is many times the strength of the material, this equation may be used for calculating the piezo-thermal effects in solids. A table is given showing the values of $\partial T/\partial p$ under these three conditions for N, H, H_2O (the latter at 1 and at 4000 megabars), kerosene and lead (at 4000 megabars). According to Bridgman, antimony, at certain pressures, is extruded through a small opening slowly and regularly; but if the pressure is raised to a certain critical value, the antimony comes out with almost explosive violence, as a long, continuous wire. The temperature rise for isenkaumic expansion of antimony is about 70° per 1000 megabars. The above critical pressure was 10,000 megabars or more; and it seems possible that, in spite of heat losses, the antimony was raised to 630° C., its melting-point at ordinary pressure. H. N. A.

711. *Revised Equation of State.* **A. W. Porter.** (Phil. Mag. **44.** pp. 1020–1024, Nov., 1922.)—Dieterici's characteristic gas equation in reduced form is $\alpha = \gamma/(2\beta - 1)$ exp. $2(1 - 1/\gamma\beta)$, which can be modified by putting γ^n for γ in the exponential term. The author rewrites it $\alpha = \gamma F(\beta)$ exp. $1/\gamma^n\beta$ where F is a function of the volume alone, so that $\gamma\partial\alpha/\alpha\partial\gamma - 1$ becomes $-n/\gamma^n\beta$ whatever F may be. Calling this quantity l, the value of βl should be a constant, whereas the author finds on plotting βl against $1/v$ for isopentane determined experimentally that it varies considerably and fluctuates near the critical point, but a smooth curve drawn amongst the calculated points shows that an equation of *at least* the second degree is required to represent them. The equation is fairly satisfactory at low pressures for $n = 3/2$, but breaks down above the critical value, making the critical volume only twice the least volume of the liquid, while experiment shows it to be mostly nearly four times. Berthelot's equation, $\alpha + 16/3\gamma\beta^2 = 32\gamma/(\beta - 1/4)$, based on experiment instead of theory, is explicitly applicable to low pressures only, and for them is much used. It does not pass through the critical point $(\alpha = \beta = \gamma = 1)$. If the necessary terms are introduced into Dieterici's equation, the equation for the critical isotherm takes the form $\alpha = \lambda(\beta - 1/4)$ exp. $(-a/\beta - b/\beta^2 - c/\beta^3)$. The three conditions for the critical point are satisfied if $\lambda = 3{\cdot}5$, $a = 1{\cdot}51$, $b = 0{\cdot}267$, $c = -0{\cdot}237$. The negative value of c is also required for the isotherm. The values of a, b, c will be functions of T. Now



$$\partial(\alpha\beta)/\alpha\beta\partial\beta = -0{\cdot}25/\beta(\beta - 0{\cdot}25) + a/\beta^2 + 2b/\beta^3 + 3c/\beta^4,$$

which vanishes for $\alpha = 0$, $\beta = \infty$, and $\therefore$ $\partial\alpha/\partial\beta \neq 0$, $\partial(\alpha\beta)/\partial\alpha = 0$ for $\alpha = 0{\cdot}25$. If $a_1 \equiv a\gamma^n$, this occurs when $\gamma^n = 4a_1 = (2{\cdot}455)^2$. Now the

$\alpha\beta$ against α curve for N starts out horizontally for $\gamma = 2 \cdot 54$; hence $n \doteqdot 2$. For these values the equation nearly becomes Berthelot's at low pressures. For it can be written $\alpha + 5 \cdot 28/\gamma\beta^2 = 3 \cdot 5\gamma/(b - 0 \cdot 25)$ for β large, and in Berthelot's equation the numbers are 5·33 and 3·55, respectively. If $b_1 = b\gamma^m$, $c_1 = c\gamma^q$, $\gamma\partial a/a\partial\gamma$ at the critical point is

$$1 + na_1 + mb_1 + qc_1 = 1 + 3 + \cdot 267m - 0 \cdot 237q.$$

Data are wanting to evaluate m and q. But the critical slope for all substances $\doteqdot 7$, so that m cannot be less than 10, and the isopentane experimental curves indicate a value between 12 and 15. The critical isotherm calculated from the values of the constants obtained above is shown in the diagram as a continuous curve. How nearly it fits the measurements for isopentane down to about half the critical volume is shown by the circles which represent experimental points. Below are values obtained experimentally and from the several equations:

Experiment.	Van der Waals.	Dieterici.	Porter.
$\alpha = 2 \cdot 15$	4	Infinity	1·56
$\alpha\beta = 1 \cdot 07$	2	Infinity	0·782

G. W. DE T.

712. *The Third Law of Thermodynamics. Evidence from the Specific Heats of Glycerol that the Entropy of a Glass Exceeds that of a Crystal at the Absolute Zero.* **G. E. Gibson and W. F. Giauque.** (Am. Chem. Soc., J. 45. pp. 93–104, Jan., 1923.)—Reasons were given in a previous paper, by Lewis and Gibson [Abstract 1622 (1920)] that Nernst's third law should be re-stated in the form: "If the entropy of each element in some crystalline form be taken as zero at the absolute zero, the entropy of any pure crystal at the absolute zero is zero, and the entropy of any other substance is greater than zero." The experimental evidence is now amply sufficient to establish the third law in so far as it applies to crystalline substances [Abstract 2112 (1922)]. This, however, cannot be said of the evidence in favour of the inequality expressed in the third law. Experiments by Gibson and others on the specific and latent heats of crystalline and amorphous alcohol and silica, etc., point to the conclusion that the entropy of the amorphous form is appreciably greater at liquid hydrogen temperatures than that of the crystals, but the uncertainties in some of the measurements are too great to allow them to be regarded as a decisive confirmation of the existence of an entropy difference at the absolute zero. Careful determinations have therefore been carried out on the specific heats and heats of fusion of "glass" and of crystals of carefully purified glycerol, and the entropy difference ΔS calculated from the equation

$$\Delta S = \Delta H\ (\text{fusion})/T_{\text{M.P.}} - \int_{T}^{T_{\text{M.P.}}} [C_p\ (\text{glass}) - C_p\ (\text{crystals})] d \log T.$$

The heat of fusion ΔH was found to be 4370 calories per mole at the melting-point 291·0° K. The first term of the above equation is thus 4370/291 = 15·02 cal./deg. The value of the integral (which was evaluated graphically) between 70° K. and the melting-point was 9·39 cal./deg. Hence $\Delta S_{70°} = 15 \cdot 02 - 9 \cdot 39 = 5 \cdot 6$ cal./deg. per mol, or 0·40 cal./deg. per mean gramme atom. We may say with confidence (from the form of the curve connecting C_p with T) that this difference of 5·6 cal./deg. between the two forms persists without great change to the absolute zero. The evidence furnished by glycerol is, therefore, strongly in favour of the interpretation of the third law given by Lewis and Gibson. T. B.

713. *Partition of Energy.* **C. G. Darwin and R. H. Fowler.** (Phil. Mag. 44. pp. 823–842, Nov., 1922.)—This is the second of a series of papers. [For the first see Abstract 65 (1923).] In summarising the first paper the authors generalise the partition function, to deal with questions of external work, by associating with each cell a definite energy, depending on the cell and on certain parameters $x_1, x_2 \ldots$. Then if p_r is the weight and e_r the energy in the rth cell, they define as the partition function by the equation $f(z) = \sum_r p_r z^{e_r}$, where z is a complex variable, summed over all permissible states. The partition function for a group N of such systems is $[f(z)]^N$. It is here shown that for every group of systems in an assembly in statistical equilibrium I must have one and the same real value θ, which is the temperature of the assembly measured on a special scale, and is connected to the absolute temperature T of the second law of thermodynamics by the relation $\theta = e^{-1/kT}$. For systems of classical mechanics the extensions of the cells, *i.e.*, the p's altered to zero, and the sum is replaced by an integral. These functions are the equivalent, with a different notation, of the *Zustandsumma* of Planck. After establishing the relation between θ and T, three sections are devoted to a critical study of the usual presentation of entropy in statistical theory, *viz.* through Boltzmann's hypothesis, which relates it to probability. Although raising no objection to much of the work based on this hypothesis, the authors take the view that the development is often marred by somewhat loose reasoning. The authors point out how greatly the possibility of combining assemblies together at will has facilitated the examination into the validity of the arguments. Two important conclusions resulting from this discussion are that Boltzmann's hypothesis can have a strict meaning only under certain conditions, shown later to be those of Gibbs' *canonical ensemble*. There is one way only of strictly establishing the relation between absolute temperature and entropy, and that is to evaluate dQ, the element of heat, for a assembly of *more than one* variable from statistical principles, and to show that a certain unique function, an arbitrary constant multiplier of course excepted, of the temperature θ is an integrating factor for it. The use of functions with the increasing property can apparently never lead to precise results without this appeal to dQ. The above discussion leads to a strict formal proof, almost in its most familiar form, of the identity of entropy as defined thermodynamically with the statistical entropy defined in the paper, and the rest of thermodynamics follows in due course, so long as the assemblies considered are of such types as to be representible by partition functions. But the mathematical proof can now be greatly simplified by making the fundamental definition not that of entropy but of Planck's *characteristic function* Ψ, closely allied to the *free energy* and defined in thermodynamics by $\Psi = S - E/T$. It has the properties $E = T^2\partial\Psi/\partial T$, $S = \Psi + T\partial\Psi/\partial T$, $X_1 = T\partial\Psi/\partial x_1$, where E is the energy of the assembly, S the entropy, and the X's are the associated forces, the external fields being defined by the x's. Now, defining *the characteristic function for any part of an assembly as k times the sum of the logarithms of the partition functions of all the component systems of the part when the argument of the partition functions is* $\theta = e^{-1/kT}$, it can at once be shown, simply by putting $\Psi = k\Sigma_r M_r \log f_r(\theta, x_1, x_2 \ldots)$ and changing from T to θ, that the thermodynamic processes are mathematically equivalent to those carried out from the statistical aspect. It is then shown that for an assembly in a temperature bath the authors' method is exactly equivalent to Gibbs' use of his *canonical ensemble*, and finally, the possibility of inverting the argument, to obtain information about the elementary states from thermodynamic data, is briefly considered. G. W. DE T.

714. *Partition Functions for Temperature Radiation and Internal Energy of Crystalline Solid.* **C. G. Darwin** and **R. H. Fowler.** (Cambridge Phil. Soc., Proc. 21. pp. 262–273, Nov., 1922.)—This is a supplement to a series of papers by the same authors now in course of publication in the Phil. Mag. [see preceding paper]. In some introductory references to them the authors emphasise the fact that for every type of system in an assembly—free atom, Planck vibrator, rotating molecule, etc.—there exists a partition function which is typical of the system, and depends on the motion of that system alone, so long, that is, as it is not too frequently interfered with, a proviso which is fundamental in all statistical calculations. *Partition Function for Temperature Radiation.*—The radiation energy in any enclosure may be regarded as that of the ether, a single system, controlled by electrodynamic laws, and specified by an infinite number of coordinates, one of which corresponds to each component train of S.H. waves, each with a definite frequency, and since the general equations are linear, it is independent of all the others. To quantise the system, therefore, each coordinate must be treated like a single Planck line vibrator of appropriate frequency. On these assumptions the partition function $R(z)$ can be written down in the form $R(z) = exp.\left\{-\Sigma_r n_r \log(1 - z^{h\nu_r})\right\}$, on the assumption that the series converges, as is found to be the case since $|z| < 1$. The coordinates are counted from the known result that for the group of frequencies between ν and $\nu + d\nu$, $n \doteqdot 8\pi V\nu^2 d\nu/c^3$, where V is the volume of the enclosure and c the velocity of light. Effecting this and proceeding to the limit $d\nu \longrightarrow 0$, we have $R(z) = \exp.\left\{-8\pi V/c^3 . \int_0^\infty \nu^2 \log(1 - z^{h\nu})d\nu\right\}$. But $-\log(1 - z^{h\nu})$ can be expanded in an infinite series, and then integrated term by term, since $|z| < 1$. Ultimately

$$R(z) = \exp.\left\{8\pi^5 V/45c^3h^3(\log 1/z)^3\right\}.$$

From this the Stefan-Boltzmann law of total radiation with the usual value $\sigma = 8\pi^5k^4/15c^3h^3$ for Stefan's constant is easily obtained. Again, writing $R(z) = R_1(z)R_2(z)$, when $R_1(z) = \exp.\left\{-8\pi V/c^3 . \nu^2 d\nu(1 - z^{h\nu})\right\}$, Planck's law, $E_\nu = 8\pi h\nu^3/c^3(e^{h\nu/kT} - 1)$, is obtained just as easily. And these results are obtained without any appeal to the mechanism of energy exchange, *i.e.* of radiation and absorption and, moreover, no appeal to thermodynamic laws except in so far as requisite for the definition of T. The present deduction of the Stefan-Boltzmann makes no assumption about the existence or magnitude of the radiation pressure.

That it must exist follows from purely thermodynamic arguments. That its magnitude must be given by the usual formula ($pV = \bar{E}_R/3$) follows from the Stefan-Boltzmann law, here deduced as a theorem in statistical mechanics. The entropy of the temperature radiation may be deduced directly from the formulæ of the authors' second paper [*l.c.*]. Ignoring the entropy-constant, any system (here the radiation) with partition function $R(\theta)$ contributes to the entropy

$$S = k\left\{\log R(\theta) + \log 1/\theta \,.\, \theta d \log R(\theta)/d\theta\right\} = 32\pi^5 k^4 VT^3/45c^3h^3 = 4/3 \,.\, \bar{E}_R/T,$$

in agreement with the usual formulæ.

Partition Function for a Crystal.—Following Born [Dynamik der Kristallgitter, Ch. V], a crystal may be taken as built up of N congruent cells, each containing s atoms, ions, or electrons. The internal motions can, he shows, be specified by $3s$ sets of normal coordinates, and the frequencies of each set, N in number, are distributed uniformly through a 3-dimension phase space ϕ, χ, ψ $(-\pi \leqslant \phi, \chi, \psi \leqslant \pi)$. The three variables represent the variations of $\nu_j (j = 1 \text{ to } 3s)$ with the wave-length and direction of propagation of the corresponding wave in the crystal. This analysis is, of course, an approximation valid only so long as the internal motions are not too violent, *i.e.* the crystal is not too hot. Any normal coordinate is as in the radiation problem, and as there, we may ignore the possible coincidences of frequencies. In any one of the $3s$ sets the number of frequencies $\nu_j(\phi, \psi, \chi)$ in a phase space element is $Nd\phi d\psi d\chi/(2\pi)^3$, and the partition function for the set and thence for the whole crystal are obtained as in the radiation problem, the latter being $K(z) = \exp.\left\{-N/(2\pi)^3 . \sum_{j=1}^{3s} \iiint_{-\pi}^{+\pi} \log (1 - z^{h\nu_j}) d\phi d\psi d\chi\right\}$. The authors outline Born's method of approximating to this, and point out that it leads to the usual general formulæ for the entropy, internal energy, and specific heat of a crystalline solid. As the necessary partition functions can be constructed, such crystals may form part of any assemblies discussed by the authors' general method, a fact which is utilised in the third and fourth papers of the series. The paper concludes with a further critical examination of the validity of using partition functions when obtained by limiting processes. It will well repay perusal, but is not suitable for abstracting. G. W. de T.

SOUND.

715. *Sound Produced by Metallic Filaments Electrically Heated.* **E. Ludin.** (Arch. des Sciences, 4. pp. 383–385, Sept.–Oct., 1922. Paper read before the Soc. Suisse de Physique.)—The author refers to certain interesting observations relative to the emission of acoustic vibrations from wires traversed by alternating currents. A. B. W.

716. *The Harmony of König Tuning-Forks.* **E. Waetzmann.** (Phys. Zeits. 23. pp. 382–386, Oct. 1, 1922.)—The Physical Institute of Breslau possesses a set of König tuning-forks which have a range from $c_3 = 1024$ to $c_5 = 4096$. A large number of valuable observations have been accumulated, and now find publication, accompanied by theoretical treatment. H. H. Ho.

717. *Tones of Metal Tubes of Pressed Spiral Strip.* **P. Cermak.** (Phys. Zeits. 23. pp. 394–397, Oct. 15–Nov. 1, 1922.)—The tones produced by flowing through helically wound metal tubes of pressed stuff are conditioned by the number of windings per second passed by the air stream. But in a tube of given length only those tones are pure and powerful whose frequencies are an exact multiple of that of the fundamental of the pipe. [See Abstract 2117 (1922).] E. H. B.

718. *Tone-Production by Pipes with Circular Apertures through the Periodic Emission of Vortices.* **F. Krüger** and **E. Marschner.** (Ann. d. Physik, 67. 5–8. pp. 581–611, June 29, 1922.)—The paper relates to the note emitted by a stream of fluid issuing through the circular aperture of a tube with its end nearly closed by a plate of diameter slightly less than the bore. By analogy with previous experiments with straight slits, the mode of production was suspected to be the periodic emission of vortex rings from the inner and outer edges of the aperture alternately. This was found to be the case, the rings being made visible, in air by the use of ammonia and hydrochloric acid, and in water by permanganate. From similarity considerations, ND/U, where N is the frequency, D the breadth of the aperture, and U the velocity of the issuing stream, was expected to be constant. This was so, the constant being 0·055 for both air and water. When the issuing stream impinges on a circular tongue, distant f, Nf/U is found to be constant, as expected, its value being 0·38. The vortices put in evidence in the first series of experiments provide an explanation of the oscillation of the jet from side to side of the tongue. A sudden rise in pitch of an octave, found to occur as f is increased, is also explained, as occurring when f is equal to twice the natural distance between successive vortices. W. G. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

719. *Proof of a Heaviside Theorem in Electrical Theory.* **H. A. Lorentz.** (Nat. Acad. Sci., Proc. 8. pp. 333–338, Nov., 1922.)—In the *Electrical Papers*, Vol. 2, p. 412, Heaviside states, without proof, the following theorem: "The whole work done by impressed forces suddenly started exceeds the amount representing the waste by Joule-heating at the final rate (when there is any), supposed to start at once, by twice the excess of the electric over the magnetic energy of the steady field set up." This proof is the outcome of an appeal to the author from an American student of Heaviside's *Electrical Papers* who had accepted and utilised the theorem in a research on "Radiation from Transmission Lines," as yet unpublished. The author assumes the matter to be isotropic, giving one dielectric constant ϵ, one permeability μ, and one conductivity σ^2. They, as well as E, H, etc., together with two kinds of impressed forces, F_1 producing dielectric displacement, and F_2 producing conduction currents, are assumed to be continuous functions of the coordinates. Then we have (1) $D = \epsilon(E + F_1)$ and $C = \sigma(E + F_2)$; (2) the fundamental field equations; (3) the electric and magnetic energies per unit of volume ($D^2/2\epsilon$ and $(BH)/2$). The Joule-heat and work of F_1 and F_2, all per unit of volume and unit of time $\left\{C^2/\sigma, (F_1\dot{D}), (F_2C)\right\}$. Suppose F_1 and F_2 started during an infinitely short time interval Δt, ending at $t = 0$; from this latter onward they remain constant. Finally there will be a steady state. Thus the time integrations must be extended up to an instant t at which the final state has been practically reached. The main point in the subsequent reasoning is that, when the interval Δt is infinitely short, the values of D and B at the instant $t = 0$ are also infinitely small, so that we may reckon with $D = 0$, $B = 0$, for $t = 0$; moreover, at $t = 0$ the current C cannot be infinite, and so we may neglect the work of the forces F_1 and F_2 during the interval Δt. In the time integral representing the work (up to the time t), we may take $t = 0$ for the lower limit. It is pointed out that the theorem can easily be verified in simple cases, when all quantities involved can be completely calculated. Examples of this type are given. There are also valuable notes dealing with the initial assumptions and with steps in the solution.

G. W. de T.

720. *Electric Fields due to Motion of Constant Electromagnetic Systems.* **S. J. Barnett.** (Phil. Mag. 44. pp. 1112–1128, Dec., 1922. Paper read before the Am. Phys. Soc., 1922.)—Starting from Maxwell's equation for the electromotive intensity and a theorem which he derived from it, the author investigates a number of simple but fundamental fields, some of which are new. Consider an electromagnetic system D having velocity v relative to fixed axes C. Let E, E′, B, B′, ψ, ψ', and A, A′ be the electromotive intensities, magnetic inductions, and scalar and vector potentials observed at a point P fixed in C by an observer respectively fixed in C and moving with D. Then $E = A - \dot{A}/c - \nabla\psi$

and $E' = -(\dot{A}')/c - \nabla\psi' - [vB']/c$, where $(\dot{A}') \equiv \dot{A} + (v\nabla)A$. The electromotive intensity at P, if fixed to D, is, to an observer in C, $E + [vB]/c$, and to an observer in D, $E' + [vB']/c$. Assuming a relativity principle according to which $E = E'$, $B = B'$ (so that also $A = A'$), Maxwell showed that the motion produces, to an observer on C, an electric field whose polar part is derivable (approximately) from the potential $\phi = \psi - \psi' = (Av)/c$. Larmor has shown that the error is of the second order in v/c. If D be unelectrified as well as being a constant electromagnetic system, which the author henceforth assumes, $E = (v\nabla)A/c - \nabla(Av)/c = E' = [Bv]/c$. Thus A, and consequently ϕ, can be determined by either or both of the equations $A = \int i d\tau/cr$, where r is the distance from an element of space (volume, surface, or length) $d\tau$ in which the current density (volume, surface, or line) is i; $\int(A dl) = \int(B dS)$, where dl is the element of length of a closed curve bounding the surface whose area is S. Now if σ be the density (volume, surface, or line) at any point of the system where the current density is i, we have $\phi = \int \sigma d\tau/r = \int(iv)d\tau/rc^2$, so that $\sigma = (iv)/c^2$. From this it follows that in the general case the electric moment Q of the charges developed by the motion is given by the equation $Q = [vM]/c$, where M is the magnetic moment. Twelve special cases are discussed, and it is also shown that, although Maxwell's theorem, $\phi = (Av)/c$, cannot in general be applied immediately to an electromagnetic system forming a solid or surface of revolution about an axis of symmetry, and in steady rotation about this axis, it is applicable to each element of which the system is composed and which has its own v and A. This last leads to the discussion of some interesting points. A large number of references connected with the subject are given together with sone criticisms of a recent paper [Abstract 1635 (1920)] by W. F. G. Swann. G. W. DE T.

721. *Equations of Propagation for a Dielectric in an Electric and a Magnetic Field.* **A. Pontremoli.** (Accad. Lincei, Atti, 31. ii. pp. 189–195, Oct., 1922.)—Develops the Maxwell equations for the case where the superposed electric and magnetic fields are both longitudinal, *i.e.* parallel to the line of propagation of a polarised beam in an isotropic medium. The resultant expressions differ from those for purely magnetic rotatory power by a term involving the ratio between the dielectric displacement of the polarisation electron under the electric field and the wave-length of the incident light. Applying these equations, **Pontremoli** (*ibid.* pp. 434–440, Nov. 5, 1922) finds the indices of refraction and the coefficients of absorption of the two circularly polarised components. The presence of the electric field alters the magnetic rotatory power, the position of the double line, and the ellipticity; these effects are, however, extremely small. A. D.

722. *The Born-Lertes Dipole Rotation.* **G. Breit.** (Zeits. f. Physik, 11. 2. pp. 129–130, 1922.)—Born has shown that, in a rotating field, a substance composed of dipoles is acted on by a couple [Abstract 1029 (1920)]. Lertes has measured this couple, and finds that the value obtained agrees satisfactorily with the theory [Abstract 975 (1922)]. The author shows that Lertes' experiment only proves a phase lag in the polarisation, as compared with the phase of the field. He shows that the polarisation $P = (\alpha - i\beta\omega)K$, where α and β are independent of ω

and $K = E + 4\pi P/3$; E is the electrical field intensity. This is the case for the dipole, and also for the electron theory. The lag in phase is $\theta = \tan^{-1}\beta\omega/a$; the moment per unit volume is $PK \sin\theta$. The Lertes experiment only proves the existence of β; and is thus a measurement of dispersion. H. N. A.

723. *Disturbed Electron Orbits in an Electromagnetic Field.* **P. Das.** (Calcutta Math. Soc., Bull. 12. 4. pp. 203–208, March, 1922.)—Assume a nucleus and one valency electron; assume the valency electron uninfluenced by the remaining electrons; assume the external electromagnetic field to consist of a plane polarised wave; assume the orbit to be circular; deduce the equations of motion. Solve for some particular cases. The general solution would be of the type $\sum_{pq} B_{p1q} \cos(pn + qn_1)t$. If the external electromagnetic wave is of nearly the same frequency as the orbital motion of the electron, the effect of the field is to cause a slow periodic disturbance in the elements of the orbit. On a collision, instead of a sharp line we shall have a diffused line; but this will be less well marked the higher the temperature. The phenomena of resonance radiation also become intelligible. A. D.

724. *A New Method for the Determination of e/m.* **H. Busch.** (Phys. Zeits. 23. pp. 438–441, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag, Leipzig, Sept., 1922.)—The method now described for the determination of the specific electronic charge has been worked out because of the need for the quantitative measurement of this important natural constant in lecture and practical work. The determination has been carried out with kathode rays, and depends on the simultaneous measurement of the discharge potential and the magnetic deflection; the deflecting field, however, was not transversal, as is usual in these measurements, but longitudinal, since work with Braun tubes had shown that a bundle of diverging kathode rays were rendered convergent by a longitudinal magnetic field. Experimental arrangements are described in detail. The data obtained proved very satisfactory for the purposes required. H. H. Ho.

725. *André-Marie Ampère.* (Rev. Gén. d'Él. pp. 11–139, Nov., 1922. Special Number.)—A series of articles dealing with the life and work of Ampère. W. R. C.

726. *Residual Charge of Dielectrics Solidified in a Strong Electric Field.* **M. Satô.** (Tôhoku Univ., Sci. Reports, 11. pp. 159–172, June, 1922. In English.)—The residual charge of dielectrics was examined by M. Eguchi [Abstract 175 (1922)]. Melted dielectrics (e.g., beeswax and resin) were solidified in a strong electric field between two parallel metallic plates and the residual charge was strong and remained after some years almost undiminished. It was concluded by Eguchi that these dielectrics were in a permanently polarised state. The author of the present paper has continued the investigation, using Eguchi's method, and tested a mixture of carnaüba-wax, beeswax, and resin in equal parts, which was melted in a shallow copper vessel and allowed to solidify in a strong electric field. When solid, it was removed, and found to be electrified oppositely on the two surfaces, and thus apparently polarised. Carnaüba-wax, resin, and a mixture of these two were similarly solidified in an electric field. It was found that according to the modes of solidification and the direction of the applied electric field they were electrified positively or negatively. The permanent electrification is considered to be due to the ions held fixed during the solidification of the wax. There is no evidence that the effects are caused by residual polarisation in the usual sense of the words. The charge disappeared on exposure to X-rays for a time, but on shaving off a thin layer of the material the charge reappeared. Thus the internal residual charge is not dissipated by exposure to X-rays, but for a time the opposite ions in the air adhere to the surface of the specimens while under the action of the X-rays, causing an apparent neutralisation. J. J. S.

DISCHARGE AND OSCILLATIONS.

727. *Kathode Disintegration*. **Research Staff of the General Electric Co., London.** (Phil. Mag. 45. pp. 98–112, Jan., 1923.)—The disintegration of a tungsten kathode struck by positive ions of various gases at various speeds is investigated by using as the disintegrated kathode the "grid" of a triode. The results obtained lead to the following conclusions: The rate of disintegration is independent of the temperature of the kathode. The rate of disintegration is a definite function of the nature of the positive ions and of their energy, increasing with the latter. There is no evidence that S is zero for any value of V_0 less than the ionisation potential, and there is no evidence of any exceptional change in S when V_0 is in the neighbourhood of the normal kathode fall, which varies from about 140 volts for Ne to 330 for H_2. Further, there is no immediately obvious connection between S for a given V_0 and the other properties of the ion. In general, S increases with the mass of the ion, but the order of Ar and Hg, and, probably, of Ne and K are exceptions. Again, the inactive gases appear especially active in disintegration, but here He is an exception. On the other hand, it appears that the metals may be especially inactive. The gases investigated show the following order of increasing rate of disintegration: hydrogen, helium, nitrogen, neon, mercury vapour, argon [see also Abstract 1690 (1922)]. These relations are very puzzling and no theory to explain them is at present offered. But it is suggested that the facts as they stand throw some light upon unsettled problems of the unsupported electric discharge. Thus, in that form of discharge, the loss of mass by disintegration per coulomb carried between the kathode and anode is proportional to $V - V'$ where V is the potential between the electrodes, and V' of the order of the normal kathode fall. There is practically no sputtering so long as the kathode fall is normal. Interpreted in the light of the present experiments, this means that with a normal kathode fall, either the current at the kathode is conveyed almost wholly by electrons, or, more probably, that the positive ions arrive at the kathode with energies far less than that corresponding to the normal kathode fall. It is only when the kathode fall is abnormal that the positive ions strike it with any considerable velocity. Again, the reduction of the disintegration with abnormal kathode fall in the inactive gases due to the presence of small quantities of impurity must mean either that the energy of the ions arriving at the kathode is reduced or that ions of the impurity, rather than of the active gas, carry the current to the kathode. Since Hg is as effective as other impurities, the first alternative seems the more probable. Generally,

measurements of disintegration will enable a distinction to be made between current conveyed by positive ions arriving at an electrode and by electrons leaving it. In the hope of applying the knowledge gained to such problems, it is proposed to continue the experiments, in particular to get a more definite relation between S and the energy of the ions. [For earlier work see Abstract 1739 (1912).] A. E. G.

728. *Secondary Kathode Radiation.* **M. Baltruschat** and **H. Starke.** (Phys. Zeits. 23. pp. 403–416, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag, Leipzig, Sept., 1922.)—This paper is a reply to Lenard's criticisms of work on secondary kathode rays which Starke and Austin published in 1902. Lenard's objections are first enumerated and discussed, especially those concerning the employment of the induction machine. A large number of eminent investigators are cited as having made very exact measurements using this instrument, *e.g.*, Kaufmann, Cady, Thomson, Wien, Guye, etc. The authors mention in this paper two directions in which false results are now indicated; (1) By perpendicular incidence the measurements are almost independent of primary velocity and the state of polish of the reflector surface, while at oblique incidence both factors are of appreciable influence. From this the conclusion was drawn that at oblique incidence secondary radiation occurred, but reflexion alone at perpendicular incidence, a conclusion now known to be invalid, secondary radiation taking place under both circumstances. (2) The secondary radiation was held to possess a very high velocity, a deduction now proved to be otherwise. The present experimental investigation relates to the velocity distribution in the back radiation of a metallic reflector, and a discussion is given with respect to the fraction of this radiation, which is scattered for different velocities of the primary rays, and the fraction which consists of secondary rays. Experimental arrangements are very fully described, and tables of results included. Measurements with the induction machine give the same results for secondary radiation as in high vacua with glowing kathode and high-tension accumulator or machine. With primary tensions of about 6000 volts slow radiation is almost exclusively emitted, while at higher tensions much more rapid radiation ensues which is to be regarded as scattered. The slower radiation decreases in amount as the primary velocity increases. H. H. Ho.

729. *"Magnet Canal Rays" and Insulator Discharges.* **E. Goldstein.** (Zeits. f. Physik, 11. 3. pp. 177–187, 1922.)—In two previous papers [see Abstract 1539 (1919)] the author has dealt with the light phenomena at anodes in discharges, and has shown that these form a special group of discharge phenomena, *viz.* as peculiar shaped discharge appearance from insulating solids, such as glass, non-conducting minerals, etc., projecting into the discharge space. Their forms deviate essentially not only from the oft described discharge appearances at metallic electrodes, but also from those observed at charged glass walls, glass rods, etc. In the present paper various forms of discharge tubes are described and illustrated, and there are also numerous photographs of the discharge phenomena described. The so-called "magnet canal rays" which are observed round the anode, in and near the equatorial plane, are bright, new, positive rays. In hydrogen these rays are rose-coloured, in nitrogen chamois-yellow, and in oxygen greenish yellow. It appears that the surface of the anode is the place of origin of these rays, but a definite decision on the matter is postponed. The appearances here described may help towards a solution of the problem and also make more clear the close connection between these new rays and the ring-formed insulator-discharges. A. E. G.

730. *Theory of Scattering of Corpuscular Rays.* **G. Wentzel.** (Phys. Zeits. 23. pp. 435–436, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—Three cases of the scattering of corpuscular rays are distinguished and discussed, *viz.*: (1) Simple, in which the particles while passing through the scattering zone undergo only single deviation, their average free path being greater than the thickness of the zone. This case has been experimentally and theoretically studied by Rutherford and his co-workers for α-rays. (2 and 3) Compound scattering, where the free path is smaller than the zone thickness, and here two sub-cases are considered according as to whether the free path is of similar dimensions to the zone thickness, or much smaller by comparison. Lenard's experiments with kathode rays here come into account. Crowther and Schonland's recent work receives careful consideration, and exception is taken to their hypothesis of a mutual effect between atom and β-electron to explain deviations exhibited by the lighter elements from the dependence of the scattering angle on the zone thickness and the ray energy. Crowther's measurements have been repeated by the author for gold, two graphs of results being included. It is pointed out that no theory has yet been published which takes account of the geometrical form of the scattering zone, a fact which severely limits the theories of Lenard and Thomson. The theory of back diffusion proposed by Schmidt rests only upon optical analogies, and is not in accord with the physical scattering problem, which latter is held to be equivalent to one of thermal conductivity, the same differential equation having been derived for both. H. H. Ho.

731. *The Present Position of the Schrot-Effect* (*literally, Small Shot-Effect*) *Problem.* **C. A. Hartmann.** (Phys. Zeits. 23. pp. 436–438, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—This effect concerns the discharge procedure of an arbitrary passage of electric carriers. The latter are considered as being very numerous and homogeneous with free paths large compared with the distance apart of the electrodes [see Abstract 1920 (1921)]. On the assumption that in the passage of a charge quantum between anode and kathode no actual connection exists with any other particle, the oscillator energy is calculated by Schottky's method. An experimental arrangement is described for testing the theoretical results, and curves of data are included. Theory, except for a few minor corrections, has been confirmed. H. H. Ho.

732. *Scattering of Hydrogen Positive Rays, and Field of Force in the Hydrogen Molecule.* **G. P. Thomson.** (Roy. Soc., Proc. 102. pp. 197–209, Nov., 1922.)—At a pressure of less than 1/100 mm. hydrogen positive rays of 10,000 volts mean energy suffer considerable small-angle scattering in a distance of 15 cm.; this scattering is very much (10 to 20 times) greater than would have been expected on the assumption that the only forces acting are the ordinary forces of electrostatics varying as the inverse square. There must, therefore, be a field of force in the hydrogen molecule, at distances of the order 10^{-8} from a nucleus, which is much stronger than would be expected from the inverse square law. A subsidiary experiment throws great doubt on Glimme and Koenigsberger's "stoss-strahlen." A. D.

733. *Evolution of Heat and Supply of Energy during Electric Discharge through Hydrogen.* **J. K. Roberts.** (Roy. Soc., Proc. 102. pp. 72–88, Oct. 2, 1922.)—Experiment designed to test Rutherford's hypothesis that a much closer combination between an electron and a hydrogen nucleus might occur [Abstract 1227 (1920)] than that existing in the hydrogen atom. If it did occur, liberation of energy might be expected, to a measurable extent in a hydrogen discharge tube. But it was found that the heat produced and the energy supplied agreed, after all corrections, within ½ per cent., which was within the error of the experiment. A. D.

734. *Impact Ionisation by Low-Speed Positive H-Ions in Hydrogen.* **A. J. Saxton.** (Phil. Mag. 44. pp. 809–823, Nov., 1922.)—Formulate the conditions governing the exchange of energy when an atom is ionised by impact or by the absorption of radiation. Apply to ionisation by positive-ion impact, with the conclusion that the ionisation potential for positive-ion impact in a gas should be the same as that for electron impact. Previous workers disagree widely as to the minimum accelerating p.d. necessary for positive ions to produce ionisation. Two types of apparatus are described, the positive H-ions being produced first by electron impact in hydrogen. The results indicate that positive H-ions produce ionisation in hydrogen when accelerated through p.d.'s as low as 18 volts, and that they are much less efficient in producing ionisation than electrons under similar conditions. A. D.

735. *The Ionising Potential of Positive Ions.* **J. S. Townsend.** (Phil. Mag. 44. pp. 1147–1148, Dec., 1922.)—This must, for hydrogen, be at least 10 volts. Where the gas is at pressures lower than 8 mm., the ionising potential of the positive ions in hydrogen is above 15 volts. A. D.

736. *New Method for Studying Ionising Potentials.* **H. D. Smyth.** (Roy. Soc., Proc. 102. pp. 283–293, Dec. 1, 1922.)—The author attempts to get a direct method of analysing the products of the ionisation tube, by employing J. J. Thomson's method of positive ray analysis. The experiments were made with mercury vapour, which was introduced into the ionisation space in such a way as to prevent its diffusing into the high vacuum in the rest of the apparatus. The vapour passes from a reservoir, which is heated electrically, down a vertical tube the upper part of which is cooled by circulation of water in a surrounding coil and the lower part by a freezing mixture. Molecules which strike the walls are condensed to liquid mercury, much of which flows back to the reservoir, while the rest is caught in a trap at the bottom of the tube. Only molecules the motion of which is parallel to the axis of the tube pass on through the ionisation space, into a continuation of the vertical tube, which is surrounded by liquid air. The ions produced were driven out of the ionising chamber by an electric field, through a horizontal tube, which contained two slits, and into the brass positive ray chamber. In the first portion of this they passed between the poles of an electromagnet, the field of which could be adjusted so as to deflect them on to a narrow slit, behind which was an insulated plate connected to a Compton electrometer. A number of curves were obtained showing the relation between the rate of charging of the electrometer and the magnetic field, with different accelerating voltages on the ionising electrons. With low voltages (mean value 19 ± 2 volts) there was only one maximum on the curve, corresponding to Hg^+. Above this voltage a second maximum appeared due to Hg^{++} ions; and on one of the curves, with high accelerating voltage, a peak was found representing $m/e = 65$, which is ascribed to Hg^{+++}. There are also peaks at $m/e = 15$, and $m/e = 30$, which are probably due to air, as they are greatly reduced in intensity, when the vacuum is high. It seems probable, from comparison with zinc and cadmium, for which the ionising potentials can be calculated from spectroscopic data, that the ionising potential required to produce Hg^{++} from the neutral atom is approximately 30 volts, so that the production at 19 ± 2 volts mentioned above must be from Hg^+, which has been formed by a previous electron impact which requires 10·4 volts to ionise the atom. H. N. A.

737. *Temperature Ionisation of Elements of the Higher Groups.* **M. N. Saha.** (Phil. Mag. 44. pp. 1128–1139, Dec., 1922.)—The alkaline earths are, as a rule, more strongly ionised in the sun, in comparison with the alkali metals, than their ionisation potentials indicate. The author suggests that, since the former have two valency electrons, and the latter only one, bombardment with electrons will have a greater chance of detaching an electron from an element like calcium than from one like sodium; and that, for the same strength of the ionising agent, Ca-gas will be, roughly speaking, twice as highly ionised as Na-gas. Recombination of Ca^+ and e is shown to be more difficult than between Na^+ and e, as in the latter case an electron coming from any direction is able to combine, while with Ca^+ only one side of the atom is free to receive an additional electron. Boltzmann was of opinion that two atoms A and B only combine to form a molecule when A and B present to one another certain definite parts of their surfaces, the areas of which are $1/n_a$ and $1/n_b$ of the respective surfaces. n_a and n_b are the "steric factors" of the elements, and according to Boltzmann vary directly as the maximum valency of the element. The author makes use of the same idea in a theory of ionisation in which A is an ion and B an electron. The theory is based on the principles of thermodynamics and the quantum theory; and values for the effective ionisation potentials of the alkaline earths at different high temperatures are obtained, the results being applied to the behaviour of the lines of the elements in the sun, and in stars of different classes and of different temperatures. Other elements are considered, and in the case of silicon it is suggested as possible that the four groups of lines, found in stars at different temperatures, are due to Si, Si^+, Si^{++}, and Si^{+++}, the first being found in cooler stars and the last in the hottest. Mn^+, Mn^{++}, C^+, C^{++}, N^+, N^{++}, V^+, V^{++} are supposed to be present in stars of different classes, the doubly charged ions occurring in the hotter stars. The lines of N^{++} are very prominent in the spectra of Novæ in their later stages. It is found that the introduction of the steric factor brings down the calculated values of the temperature, for the different spectral classes, into line with those obtained from intensity measurements. H. N. A.

738. *Sparking Potential in Transverse Magnetic Fields.* **M. Wehrli.** (Arch. des Sciences. 4. pp. 361–363, Sept.–Oct., 1922. Paper read before the Soc. Suisse de Physique.)—Extension of Townsend's sparking-potential theory to the case of magnetic fields. Experimental confirmation. A. D.

739. *Counter E.M.F. in the Electric Arc.* **A. Hagenbach** and **R. Percy.** (Arch. des Sciences, 4. pp. 363–367, Sept.–Oct., 1922. Paper read before the Soc. Suisse de Physique.)—A modification of Duddell's method. Duddell's results confirmed in the main, but the numerical results greater. A. D.

740. *Light Emission from the Glow Discharge.* **R. Seeliger.** (Ann. d. Physik, 67. 5–8. pp. 352–358, June 29, 1922.)—In this paper are brought together some observations on the glow discharge partly from earlier investigations, some by J. Stark on the striated column [Abstract 897 (1922)], partly consisting of observations on the Faraday dark space not hitherto brought forward. These may be useful as helps towards an atomic theory, and also towards a knowledge of the glow discharge itself. Especially some knowledge of the partition of velocity of the electrons in the separate portions of the dark space may be attained. Various discharge tubes were used, and the discharge investigated by spectrographic means. Pure H, N, and O were examined. The boundary region between the Faraday dark space and the positive column was investigated. It was noted that the separate lines and bands from the dark space, rising to a maximum at the beginning of the column, attain the maximum at various places, in the inverted sequence as in the glow. It is frequently stated that the Faraday dark space in contradistinction to the kathode dark space is actually dark, *i.e.* without emission of light. This is by no means the case, as the theory of this space indeed would indicate. The account given may be taken as the first expression of the emission intensities in the separate parts of the glow discharge, and an attempt to make use of the ionic theory as regards the same, and to assemble together the hitherto produced optical sounding measurements which may lead later to valuable results. J. J. S.

741. *Electronic Discharge with Small Distances between Electrodes.* **F. Rother.** (Phys. Zeits. 23. pp. 423–426; Disc., 426–427, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—The author had previously measured in air at atmospheric pressure, and in a 0·5-mm. vacuum, the current between two electrodes separated by a very small distance. When this was of the order of a light wavelength, and the voltage about 10 volts, currents of about 10^{-14} amperes, which differed for different metals, were obtained. In the present work the measurements were made in very high vacua. The two electrodes consisted of very pure metal cylinders, diameter 4 mm., the ends turned towards one another being ground by the methods used in optics to highly polished convex spherical surfaces. One of the electrodes was attached to the middle of a thin sheet of platinum, which closed one end of the vacuum tube, to the glass of which its edges were fused. The slide of a Fabry and Perot interferometer was connected with the outside of the platinum disc at the centre. The pressure of the outside air on the platinum membrane pulled the slide against the screw of the interferometer, acting like a spring and preventing "back-lash." In one experiment the contacts were of platinum, radius of curvature of contact surfaces 20 mm., V = 190 volts, c about 5×10^{-14} amperes, separation 250 $\mu\mu$; the current increased very rapidly when the voltage was raised. The author suggests that the results depend on the fact that, even with small voltages, the field intensity between the contacts is very great when they are brought so near together. In the *discussion*, **W. Schottky** pointed out that for such short distances the field intensity cannot be calculated from the radius of the spherical surfaces. Microscopic and ultra-microscopic irregularities will produce effects like the action of points, greatly increasing the local field intensity. H. N. A.

742. *Behaviour at the Kathode of the Mercury Vacuum Arc-Light.* **A. Günther-Schulze.** (Zeits. f. Physik, 11. 2. pp. 74–87, 1922. From the Reichsanstalt.)—The kathode-fall of the mercury vacuum arc-light is, according to Stark, 5·27 ± 0·09 volts and is independent of the current strength. As the result of the present work it is concluded that the quantity of heat conducted from the kathode spot of the mercury vacuum arc-light to the mercury kathode is proportional to the current and amounts to 2·68 watt-sec. per amp.-sec. or 51 % of the total kathode-fall energy. The size of the kathode spot is proportional to the current and amounts to $2 \cdot 53 \times 10^{-4}$ cm.^{2} per amp. The current density at the kathode spot in round figures is 4000 amp. per cm.^{2}. The radiation from the spot is small. The loss of weight of the mercury kathode on account of vaporisation at the spot is proportional to current strength, and amounts to $7 \cdot 20 \times 10^{-3}$ gm. per amp.-sec. It requires 2·20 watt-sec. to vaporise this quantity of Hg *in vacuo* at 100° C. The total energy loss at the kathode spot is now found to be 4·92 to 4·99 watt-sec., from which it follows that nearly the whole current at the kathode is transported by Hg-ions and only a small fraction by electrons. The pressure exerted on the kathode spot by the incoming Hg-ions and the vaporising Hg-atoms amounts to 2 atmospheres. The density of the mercury vapour immediately over the kathode spot corresponds to a pressure of 0·26 atmosphere. In spite of their small number the electrons emitted from the kathode are essential for the arc existence, since the arc is a form of discharge, and it is only the negative electrons which are able to form new ions by collision. A. E. G.

743. *Magnitude of the Kathode Spot in Carbon Arc-Lights in Air.* **A. Günther-Schulze.** (Zeits. f. Physik, 11. 2. pp. 71–73, 1922. From the Reichsanstalt.)—Granquist gives the radius of the kathode spot with carbon arc-lights in air, the formula $r = 0 \cdot 043 + 0 \cdot 008i$ (cm. and amp.) for the limits 5 to 15 amp. Reich, on the other hand, finds that $r = 0 \cdot 01 + 0 \cdot 009i$ (cm. and amp.) with an arc length of 9 mm. and a carbon diameter of 6 to 7 mm. [see Abstract 563 (1906)]. He also found that the first member of the equation increases with decrease of the arc length, while the second remains constant. In the present experiments an attempt is made to ascertain the magnitude of the kathode spot as a function of the arc length for different constant-current strengths. In order to do this the kathode spot is projected upon a screen after a 22-times linear magnification. The results obtained are given in graphical form, the magnitude of the kathode spot being plotted against the arc length for 10, 7½, 5, 3, and 1·5 amp. It is concluded that when the anode is so far removed from the kathode that its rays no longer influence the size of the kathode spot, the latter is proportional to the current strength. The constant-current density of the kathode spot is found to be 470 amp./cm.^{2}. A. E. G.

744. *Electric Discharge and De-gasification of the Electrodes. X-Rays.* **A. Janitzky.** (Zeits. f. Physik, 11. 1. pp. 22–30, 1922.)—Manifold observations show that the gases occluded by the electrodes have considerable influence upon the discharge phenomena. The photoelectric effects of zinc and potassium [Hallwachs, Abstract 503 (1921)] and of mercury [Sende and Simon, Abstract 630 (1922)] vanish when the metals are freed of gas; the δ-rays given off by carbon and zinc [McLennan and Pound, Abstract 1692 (1915)] are increased at low temperature and vanish in a high vacuum, and the Volta contact potential also disappears in a vacuum [Hughes, Abstract 1884 (1914)]. The author observed during the war in Kijew that X-ray bulbs, submitted for repair, would not work unless the anti-kathode was made to serve as kathode. Experimenting with a 3-electrode bulb, he found that the third electrode D became hot and discharged gas (hydrogen); when D was heated to a red glow it would only serve as kathode, allowing no current to pass when anode, and finally, when completely de-gasified, D would not answer as kathode either. The material of the electrode, aluminium, gold, platinum, calcium, made little difference. The research was later resumed with bulbs fitted with 4 symmetrical electrodes of copper. The effect seems to depend mainly upon the anode; an exchange of the kathode did not matter. As to this the author differs from Ratner [Abstract 1778 (1921), and Phil. Mag. 43. pp. 193–204, Jan., 1922] who explains the phenomena by a kathode polarisation. With Dessauer the author believes that X-ray bulbs turn hard or soft as the electrodes inhale or exhale gas. H. B.

745. *Researches on Electric Arcs.* **W. Mathiesen.** (Review by G. Gehlhoff. (Zeits. techn. Physik, 3. 11. pp. 357–360, 1922.)—This paper consists of a review of a book written by W. Mathiesen, and published in Leipzig in 1921. Some of the results obtained in the experiments described are the following: The arc burnt under pressure, neither between pure carbon electrodes nor between various kinds of salted carbons, does not give such an improvement in the efficiency as to compensate for the increased rate of consumption of the carbons and the technical complications, independently of the rapid increase in the unstability of the arc as the pressure increases [see also Abstracts 150B (1917) and 217B (1918)]. The temperature of the gaseous part of the arc was measured by projection on to a thermo-element, and by comparison with the optically measured temperature of a rod of carbon introduced into the arc. The temperatures were found to be relatively low, and agreed well with the results obtained by melting rods of magnesium oxide (2800–3000° abs.), zirconium oxide (about 3000° abs.), and silicon carbide (about 2800° abs.). The results for 7-mm., 10-mm., 13-mm., and 16-mm. arcs with a 10-Å. current are given in diagrams. The temperature of the crater with pure carbon electrodes is considerably higher than that of the fluoride of calcium arc. The length of the arc increases with the content of fluoride of calcium up to a limiting value (saturation value of the ionisation), the voltage drop at the anode decreasing, and the temperature of the crater likewise decreasing. The secondary heating of the positive crater by radiation has the effect of increasing the ionisation and reducing the voltage drop on the anode; it also lowers the temperature of the crater, although the current remains constant and the candle-power rises considerably. The heating of the crater thus has the same effect as increasing the current. The determining factor for the temperature of the crater is the voltage drop at the anode in the layer of gas at the anode, *i.e.* its ionisation. With nearly all the curves showing the variation of the various magnitudes with pressure, there is a more or less pronounced hump at a pressure of 1 atmosphere absolute, showing that the candle-power, the radiation of energy, the voltage drop at the crater with pure carbon electrodes, the consumption of material in the arc and in a candle, and the candle-power of a candle flame are all a maximum at that pressure. C. A.

746. *Electric Arc to Mercury with a Perforated Kathode.* **A. Sellerio.** (N. Cimento, 24. pp. 165–179, Oct.–Nov.–Dec., 1922.)—An electric arc is produced between an anode consisting of a meniscus of mercury and a kathode of a very thin sheet of metal or carbon placed a short distance above it. By suitably regulating this arrangement the little column of mercury vapour which rises from the anode and is projected towards the kathode remains quiet for a short time. Under such conditions a small puncture is produced in the kathode. If the column of mercury vapour which rises from the anode is now observed it will be seen to form, above the kathode, a small flame surmounted by a high tuft of whitish fumes. This phenomenon is discussed and diagrams of apparatus are given. There are also spectrographs shown of mercury and copper, and mercury and carbon. A. E. G.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

747. *Photoelectric Conductivity in Badly Conducting Liquids.* **S. Timpanaro.** (N. Cimento, 24. pp. 203–219, Oct.–Nov.–Dec., 1922.)—The increase of conductivity caused by ultra-violet rays is different for different layers of the liquid, and is in accord with an interior Hallwach's effect. The residual charge in the liquid persists until the liquid is thoroughly mixed by means of a pipette. A. D.

748. *Theory of Metallic Conduction.* **T. Bialobjeski.** (Phil. Mag. 45. pp. 161–168, Jan., 1923.)—The paper first includes a résumé of previous hypotheses, of which the electron theory appears still to find most favour. The low temperature work of K. Onnes, however, points to grave difficulties, inasmuch as at 4° K., some metals pass into a state of super-conductivity which appears abruptly at a definite temperature. Attempts aiming at reconciliation of the theory of free electrons with experimental data cannot be regarded as satisfactory. J. J. Thomson's restated theory, in which an intermolecular field of force is introduced making the view of the conductivity of metals similar to that by which Weiss explained ferro-magnetism, is considered and criticised. The recent progress of views on the dependence of various phenomena upon temperature has led to the conviction that Planck's quanta should be introduced into all problems concerning partition of energy, and it is the object of this paper to show that the hypothesis of intermolecular fields of force, considered as an important agent of conductivity at low temperatures, becomes unnecessary if such energy quanta are introduced. It is demonstrated that if J. J. Thomson's hypothesis regarding the interchange of electrons between atoms be combined with the fundamental relations of the quantum theory, an interpretation is afforded of the essential features shown by the conduction of electricity through metals. H. H. Ho.

749. *The Hall-Effect in Anisotropic Rectangular Laminæ.* **E. Persico.** (Accad. Lincei, Atti, 31. ii. pp. 500–504, Dec. 3, 1922.)—Assuming ions $+e$ and $-e$, and replacing the scalar mobility by a tensor proper to each class of ion, the equations are worked out. An equivalent image-plane is found. The same results can be obtained with a rectangular isotropic lamina of a different form. The difference between the observed Hall-effects when transversal or longitudinal is not a proper Hall-effect difference; but it is a difference between the perturbations introduced by the electrodes, which difference tends to vanish as the lamina is lengthened in the direction of the current. With point-electrodes in a long lamina, the same coefficient would be obtained with the current parallel or transverse to the axis, both in isotropic and anisotropic laminæ. A. D.

750. *Photoelectric Conductivity.* **B. Gudden** and **R. Pohl.** (Phys. Zeits. 23. pp. 417–419; Disc., 419–420, Oct. 15–Nov. 1, 1922. Paper read at Deut Physikertag., Leipzig, Sept., 1922.)—The complicated phenomena are considerably simplified if single crystals are made use of, with small illuminations, and if attention is concentrated on the initial value of the current. It is found that, as soon as the illumination begins, the current starts without any inertia effect, and the value thus obtained is spoken of as the primary current. With the lapse of time the current alters, and the alteration is spoken of as a secondary current. The primary current becomes "saturated" as the voltage is raised, the saturation voltage being proportional to the thickness of the crystal, so that there is a definite saturation field intensity for each kind of crystal, and for each direction in a crystal. The curves showing the relation between current and field intensity seem to be independent of λ, and of the direction of the field. Experiments on a large number of crystals indicate that the saturation field intensity is related to the refractive index for red light. Interesting results are obtained with regard to the relation between photoelectric conductivity and absorption. The "output," *i.e.* the ratio between the quantity of electricity produced and the light energy absorbed, is proportional to λ from a point near the optical absorption line, out in the direction of increasing wave-length. With ZnS and HgS it was found that, within the limit of error, one calorie of absorbed light set in motion the number of coulombs of electricity which would be expected if every absorbed quantum corresponded to one electron. Thus the absorption of light in solid bodies appears to be governed by quantum relations. The phenomena in the neighbourhood of the absorption line, when μ, the absorption constant, rises suddenly to a value a thousand times as great as before, are to be dealt with by the authors in future papers. In the *discussion*, **W. Schottky** raised the question of the relation between the metal atoms and the electrons producing the current. The author agreed that the electrons are thrown off by the negative atoms, and that the action of the positive constituent of the molecule is indirect. H. N. A.

751. *Mechanism of Photoelectric Conductivity.* **F. Kaempf.** (Phys. Zeits. 23. pp. 420–423; Disc., p. 423, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—The author's method of measurement differs a little from that of Gudden and Pohl [see preceding Abstract], as the galvanometer is short-circuited during the instant at which illumination commences, in order to avoid any possible disturbance due to alteration of the dielectric constant. The primary current is then quickly measured. In order to obtain information as to the distribution of the electric field inside the crystal "probe," electrodes were introduced between the main electrodes. It was found that for low voltages the potential drop near the electrodes was greater than in the middle of the crystal, and that with increasing current the relative rate of change at the kathode increased, or the conductivity near the kathode diminished. The conclusion is drawn that the current is carried by electrons, and their mobility is calculated as about 2·9 cm./sec., or about 1/10 of that in metals. Scholl arrived at a similar conclusion from his observations on moist, illuminated silver iodide. Experiments with sulphur indicate that ultra-violet light breaks off electrons, which unite on collision with neutral molecules. These have no mobility, and so do not carry any current. They lose their electrons very slowly in the dark; more quickly in light, including that of great wave-length. Similar phenomena are probable for other substances; the formation and stability of the negative ions being most marked in electro-negative substances. Gudden and Pohl have found that ultra-red light restores diamonds, which have been altered in their properties by the action of ultra-violet light, to their original condition more quickly than when they are kept dark. Lenard makes the above assumption in explaining phosphorescence phenomena. The authors consider that in determining the saturation current it is necessary to wait until this formation of negative ions has taken place, but not so long that secondary chemical effects produce disturbances. This is not in accordance with the views of Gudden and Pohl. H. N. A.

752. *Variation of Dielectric Constants with Temperature.* **Jezewski.** (J. de Physique et le Radium, 3. pp. 293–308, Aug., 1922.)—In general the dielectric constants of liquids diminish when the temperature rises. P. Debye explains this phenomenon by supposing that each molecule contains an electric doublet, and deduces from his hypothesis the formula

$$\frac{\epsilon - 1}{\epsilon + 2} \cdot \frac{1}{\rho} = \frac{a}{\mathrm{T}} + b$$

where ϵ signifies the dielectric constant, ρ the density, T the absolute temperature, and a and b are constants. It follows that

$$\frac{\epsilon - 1}{\epsilon + 2} \cdot \frac{1}{\rho} \cdot \mathrm{T} = a + b\mathrm{T}.$$

According to this formula $\frac{e - e}{\epsilon + 2} \cdot \frac{1}{\rho} \cdot \mathrm{T}$ must be a linear function of the absolute temperature. The measurements of the dielectric constants hitherto made are insufficient for the verification of this formula, and the author has undertaken the measurement of the dielectric constants and the densities of the four liquids: aniline, nitrobenzene, glycerine, and water over an extended interval of temperatures.

The method of measurement employed was that of resonance in oscillating circuits modified to avoid certain sources of error. Two oscillating circuits are coupled together. In the primary circuit which is composed of a self-inductance and a condenser, oscillations are excited. This circuit causes the secondary circuit, which is composed of two self-inductances and a variable condenser, to vibrate. The amplitude of the oscillations thus produced attains a maximum for the capacity C and the self-induction L of the circuit, for which

$$\frac{1}{2\pi}\frac{1}{\sqrt{CL}} = n$$

where n is the frequency of the oscillations. Then the circuits are said to be in resonance. Resonance is obtained by varying the capacity suitably. The methods of avoiding certain sources of error are described. The condenser was placed in a Dewar flask filled with oil. Tables are given showing the values observed, and those got from Debye's formula. *Aniline* distilled between 181°·5 C. and 182° C., and dried for several days in a desiccator with sulphuric acid, was employed, and measurements made at various temperatures from 0° to 180°·8. *Nitrobenzene* similarly dried for ten successive days was used, and observations were made on the dielectric constant between 18°·6 and 203°·9 C. *Glycerine* was distilled under the pressure of 15 mm. of mercury and dried for ten days as the other liquids, and observations made upon it from 17° C. to 144°·5 C. The dielectric constant of *water* distilled several times was observed between 2°·3 C. and 99°·5 C. The difference between the measured values and those calculated by Debye's formula do not exceed the limit of experimental errors except in the case of nitrobenzene. The calculated values of a and b deduced from the experiments are:

	a	b
Aniline	+54·23	+0·465
Nitrobenzene	−43·18	+0·904
Glycerine	−22·52	+0·822
Water	−25·47	+1·054

Thus a has a negative value for nitrobenzene, glycerine, and water, which result is in complete disaccord with the theory of Debye. Aniline alone agrees with the formula given. J. J. S.

753. *Electrical Resistivity and Temperature Coefficient of Manganin.* **S. Kimura** and **K. Sakamaki.** (Elektrot. Lab. Tokyo, Researches, No. 114 (10 pp.), Sept., 1922. In English.)—The resistivity and temperature coefficient of copper-manganese alloys, and the effects of other elements, such as nickel, iron, aluminium, and silicon, are investigated. The authors find that a straight copper-manganese alloy gives the best manganin, and that there is no need to add other elements to improve the resistivity and temperature coefficient. The alloy containing 13 % manganese has a specific resistance of 45 michroms per centimetre cube, the temperature coefficient at 22·5° C. being 0·00000348. W. R. C.

754. *Applications of the Pyrometer in High-Frequency Measurements.* **R. Jouaust.** (Comptes Rendus, 175. pp. 1050–1051, Nov. 27, 1922.) —The author points out the practical difficulties in the use of calorimetric measurements in practical wireless telegraphy. The Féry pyrometer can, however, be used for a number of high-frequency measurements with sufficient accuracy. As examples of such measurements, the author cites the cases of calibration of high-frequency ammeters and the measurement of the circuit resistance of a thermionic valve. B. J. L.

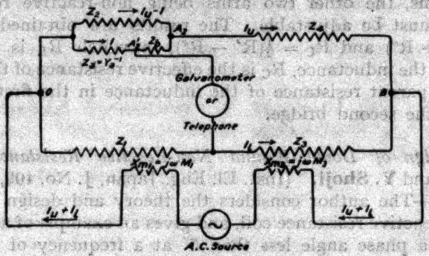
755. *A New High-Tension Generator for X-Rays.* **W. H. Wilson.** (Röntgen Soc., J. 18. pp. 143–148, July, 1922.)—A previous paper [see Abstract 1748 (1912)] showed that a coil could be interrupted almost sparklessly if its natural period of oscillation was sufficiently great. In practice this method had two limitations, first the frequency of interruption was comparatively low, as each cycle consisted of several operations; and, secondly, the extreme rapidity of condenser discharge through the primary made it impossible to short-circuit the main inductance without sparking. The present method attacks the problem from a different standpoint, one of the aims being to reduce the energy to zero before the supply circuit is interrupted, so that there is little tendency to spark. A condenser is charged through an inductance from a direct-current source, and the condenser has across its terminals a second inductance. The supply circuit of voltage V is closed by a motor-driven interruptor. It is shown mathematically that at the end of the first half-wave the current from the supply is zero, the energy stored in the first inductance is also zero, and the interruption is sparkless, so that the condenser at voltage 2V can discharge through the second inductance at the natural frequency of the circuit. If at the end of the first half-wave of this free oscillation the interruptor re-closes the circuit, the voltage 2V of the condenser is added to that of the supply, the pressure on the primary inductance is increased to 3V, and at the end of this half-wave the pressure is still further increased to 4V. Hence by arranging the periods of closing and opening of the circuit to correspond with the oscillations, a state of resonance occurs and a greatly increased e.m.f. is impressed on the primary than would be the case if the supply source acted alone. In addition there is no tendency to spark. The inverse current of this arrangement is stated to be small. The apparatus will give a 10-inch spark with a 50–60-volt portable battery, and the method was employed for wireless transmitters during the war.

B. J. L.

756. *Ballistic Galvanometer.* **A. J. Staring.** (Arch. des. Sciences, 4. pp. 376–379, Sept.–Oct., 1922. Paper read before the Soc. Suisse de Physique.)—Conditions for sensibility of ballistic galvanometers in closed circuits with damping. A. D.

757. *Use of Galvanometers for Zero Readings.* **L. Mazza.** (Accad. Lincei, Atti, 31. ii. pp. 504–508, Dec. 5 and pp. 557–559, Dec. 17, 1922.) —The telephone is generally more convenient than contrivances giving visible readings; but with thermionic valves to rectify the alternating currents the sensibility and the precision may be made much greater than with the telephone, while the rapidity of measurement is at least equal. This is due to the amplifying effect of the thermionic valve, But a thermionic valve has a high resistance, and requires a high-resistance galvanometer. Much smaller resistances may be used if the thermionic valve be replaced by a crystal-contact detector, as used in radiotelegraphy; the best is a crystal of argentiferous galena, against which a copper point is pressed by an adjustable spring. A. D.

758. *General Equations of a Balanced Alternating-Current Bridge.* **V. Karapetoff.** (Phil. Mag. **44.** pp. 1024–1032, Nov., 1922.)—The author deduces a general equation of the a.c. bridge which will include the various actual bridge arrangements as specific cases, and enable new bridge arrangements to be devised without deduction of fundamental cases or constructing vector diagrams. H. H. Poole has shown [Abstract 1303 (1921)] that the currents and voltages in the a.c. bridges in ordinary use, when balanced, can be represented by comparatively simple vector diagrams. The other side is here dealt with, the generalisation of the theory. The accompanying diagram is the so-called Anderson bridge, balanced on a.c. I and I*u* are the lower and upper branch currents. The Z's are impedances, their reciprocals the corresponding admittances, are denoted by the Y's, and the X*m*'s are the mutual inductances. Assuming currents and impedances to be expressed as complex quantities, the three fundamental equations of voltage drop are: $IZ_1 - [I_u + I_l)X_{m1} = IZ_a$, $IZ_b + I_uZ_4 = I_lZ_3 - (I_u + I_l)X_{m3}$, $(I_u - I)Z_2 = I(Z_a + Z_b)$. Eliminating the currents, we obtain as the general relation among the impedances of a balanced bridge: $(Z_3 - X_{m3})[(Z_2 + X_{m1}) + Y_aX_{m1}(Z_2 + Z_b)] = (Z_1 - Z_{m1})[(Z_4 + X_{m3})\left\{1 + Y_a(Z_2 + Z_b)\right\} + Y_aZ_2Z_b]$. This may be applied directly in any special case, but there are some for which it is easier to simplify it first, and the author gives eight examples of this, covering all Poole's cases and others and indicating whether or no there is direct current balance and the values of the Z's and X's. Assume, *e.g.*, no mutual inductances and a single shunt branch (2 in diagram). Then $X_{m1} = X_{m3} = 0 = Y_a$. Then the fundamental equation becomes



$$Z_3Z_2 = Z_1Z_4 \equiv (r_3 + jx_3)(r_2 + jx_2) = (r_1 + jx_1)(r_4 + jx_4).$$

Separating the real and imaginary parts, we have

$$r_3r_2 - x_3x_2 = r_1r_4 - x_1x_4 \quad \text{and} \quad x_3r_2 + r_3x_2 = x_1r_4 + r_1x_4.$$

Then we may put either $r_3r_2 =$ or $\neq r_1r_4$. In the first case the bridge is first to be balanced by direct current, and the first equation becomes $x_3x_2 = x_1x_4$, and the latter, together with the second equation, may be used to investigate various possible bridge combinations with resistances and inductances. In the second case the two equations may be used to investigate various bridge arrangements containing resistance, inductance, and capacity. When one or more branches contain parallel paths it is simpler to replace impedances by admittances. G. W. DE T.

759. *A Bridge Method of Determining the Effective Resistance of an Inductance Coil or Condenser.* **H. V. Higgitt.** (Electrician, 90. p. 114, Feb. 2, 1923.)—The Wien bridge method of measuring the effective resistance of an inductance coil requires a knowledge of the losses in the condenser. The author describes a method which allows the losses of the inductance coil and condenser to be separated by making use of two different forms of bridge. The inductance and capacity are first joined in series in one arm of a bridge, the other three arms of which are non-reactive resistances, one of the adjacent arms being adjustable. Either the capacity or frequency must be finely adjustable. A balance having been obtained on this bridge, another bridge is formed in which the inductance coil and condenser, unchanged in values, become the opposite arms, the other two arms being non-reactive resistances, of which one must be adjustable. The results are obtained in the form $R_L = \frac{1}{2}(R' + R'')$ and $R_C = \frac{1}{2}(R' - R'')$, in which R_L is the effective resistance of the inductance, R_C is the effective resistance of the condenser, R' is the apparent resistance of the inductance in the first bridge, and R'' that in the second bridge. W. R. C.

760. *Design of Double-Wound Non-Reactive Resistance Coils.* **H. Nukiyama** and **Y. Shoji.** (Inst. El. Eng. Japan, J. No. 409, pp. 603–615, Aug., 1922.)—The author considers the theory and design of a double-wound non-reactive resistance coil, and gives an example of a 100,000-ohm coil, having a phase angle less than 5° at a frequency of 5000.

W. R. C.

ALTERNATING CURRENTS AND MAGNETISM.

761. *Measuring Rotary Magnetic Hysteresis Losses.* **T. Miyazaki.** (Inst. El. Eng. Japan, J. No. 412. pp. 867–882, Nov., 1922.)—Many investigations have been carried out on rotary magnetic hysteresis, yet the recent results show great discrepancies. This inconsistency is thought to be due chiefly to the systematic errors of various methods of measurement. Taking the irregularity of the electromagnetic field brought into existence by the unsymmetrical forms of test pieces and Joule's effect as the chief disturbing factors, the author describes a comparatively accurate method of measuring the torque of a solid spherical test piece in a rotary magnetic field and the correction of Joule's effect. AUTHOR.

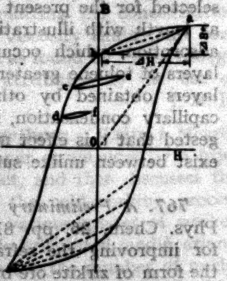
762. *Induced Polarisations.* **A. Perrier.** (Arch. des Sciences, 4. pp. 369–373, Sept.–Oct., 1922. Paper read before the Soc. Suisse de Physique.)—Induced polarisations imply corresponding moments (magnetic or electric); induced orientations do not. Comparison of conditions of reversibility and of irreversibility. Experimental verification in respect to electric dissymmetry of molecules of iron, by **A. Perrier** and **A. J. Staring** (*ibid.* pp. 373–376). An electric current provokes or modifies a magnetisation in iron which it traverses, this magnetisation being transversal to the electric field and of contrary sense; as if the iron molecules had an electric moment opposed to their magnetic moment.

A. D.

763. *Effect of Frequency on Permeability of Iron Wires.* **B. Wwedensky** and **K. Theodortschik.** (Ann. d. Physik, 68. 5. pp. 463–480, Aug. 31, 1922.)—The permeability of iron wire in weak fields is investigated for the wave-length range from 54 to 705 metres. Two high-frequency valve generators act on the grid circuit of a three-valve amplifier to set up a beat note in the telephone. A third valve generator superposes a note of audible frequency on the first note to form a secondary difference tone. When a few iron wires are placed in a coil in the oscillating circuit of the first generator, a change in frequency is caused which is neutralised by making a change of capacity in the same circuit. The permeability is derived from the observed change in capacity. The method, with three others which were also employed, brings out the fact that between λ54 and 300 metres the permeability of iron is not constant; there is a sharp maximum, for λ100, lying between two minima. In this respect the curve resembles that for the optical refractive index in an absorption band. [See also Abstract 649 (1922).]

G. E. A.

764. *Incremental Permeability.* **T. Spooner.** (Am. I.E.E., J. 42. pp. 42–47, Jan., 1923.)—Incremental permeability (μ_Δ) is defined as $\Delta B/\Delta H$, where the change of B may range from the small values required by Gans' reversible permeability (μ_r) up to large values. Referring to the Fig., for any minor displaced loops superimposed on a major loop; *e.g.*, *ab*, *ce*, or *df*, the μ_Δ will be the ratio of the difference of inductions for the two tips of the minor loops to the difference of the H values for these tips. For minor loops one of whose tips coincides with one tip of the major loop, the incremental permeability is represented by the slopes of the dotted lines shown at the bottom of the major loop. The mean slopes (μ_Δ) of these minor hysteresis loops is a function of two variables: (1) For a given ΔB the greater the displacement of the minor loop from its normal position the less the incremental permeability; (2) for a given displacement of a minor loop the greater the ΔB, the greater the incremental permeability. The author gives a number of instances where a method of estimating this type of permeability is desirable. The formula for incremental permeability is $\mu_\Delta = \mu_{B_m}(a + b \times \Delta B)$, where $\mu_\Delta =$ the incremental permeability, $\mu_{B_m} =$ the ordinary permeability corresponding to the induction of the tip of the loop farthest from zero induction; *a* and *b* are constants, and $\Delta B =$ amplitude of flux pulsation of the minor loop expressed in kilogausses. The value of *a* when B_m equals zero is unity, and approaches unity again for high values of B_m; and *b* approaches zero for high values of B_m. A series of tables gives the results of experiments on various alloys for permeability. [See Abstract 749 (1920).]



T. C. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

765. *Active Chlorine.* **Y. Venkataramaiah.** (J. Phys. Chem. 27. pp. 74–80, Jan., 1923.)—The author has prepared active chlorine by the silent electric discharge, by the ordinary electrical discharge at a pressure of 20 mm., by ultra-violet light, and by heat. The gas is more active than ordinary chlorine and is decomposed at about 50° C. Chlorine contracts in volume when it is activated. W. R. C.

766. *The Adsorption of Toluene Vapour on Plane Glass Surfaces.* **E. K. Carver.** (Am. Chem. Soc., J. 45. pp. 63–66, Jan., 1923.)—Data on adsorption of vapours are still untrustworthy for furnishing information of a decisive character regarding the nature of intermolecular forces, while the important question of thickness of the adsorbed layer is as yet not definitely settled. Most of the experimental work tends to show that this layer is many molecules deep, but Langmuir points out that the data have been obtained with porous bodies in which true adsorption is masked by the effect of the pores. Langmuir obtained data for adsorption on glass, mica, and platinum which bear out his theory that the layer truly adsorbed is but 1 or 2 molecules deep. This work was done at low temperatures and with gases which might be condensed by free valencies, so the heavier vapour of toluene was selected for the present investigation. The apparatus used is described at length with illustrative diagrams. The results show definitely that adsorption, which occurs largely at low pressures, will not produce layers of toluene greater than 1 molecule deep on glass. If the thicker layers obtained by other investigators cannot be accounted for by capillary condensation, some other effect must be sought. It is suggested that this effect might be the contact potential which appears to exist between unlike substances. H. H. Ho.

767. *A Preliminary Study of Zirkite Ore.* **J. G. Thompson.** (J. Phys. Chem. 26. pp. 812–832, Dec., 1922.)—Methods are investigated for improving the refractory properties of crude zirconium oxide in the form of zirkite ore by the elimination of the associated impurities, the chief of which are silicon, iron, and titanium. The melting-point of the raw ore varies from 1200° C. to 2000° C., while that of the pure oxide is given as 2950°–3000° C. A review is given of the methods of analysis which have been applied for zirconium compounds and a modified scheme is outlined for the separation and estimation of this oxide. The method of purification found most satisfactory is based on the fact that zirconium carbide is stable at temperatures above the decomposition point of silicon carbide. The use of a resistance furnace which was tried in the first place was abandoned for one of the arc type. The enclosure consisted of an iron pot lined with zircite ore, with a base electrode of graphite forming the hearth, and a suspended vertical electrode which enables an arc of 1000 amps. to be maintained. The charge consisting of a mixture of ore and coke, the amount of carbon being approximately that required to transform only the silicon to carbide, was fed in slowly;

and, after reacting, left a solid mass of zirconium carbide which retained some silicon and iron, was infusible at the temperature of the arc, and burnt readily in air to form a light flocculent oxide. Experiments indicated that a fairly pure oxide can be obtained by eliminating 90 % to 95 % of the silica in the electric furnace and by following this by treatment with chlorine or phosgene in a heated tube to remove the iron. J. N. P.

768. *Isoelectric Condition of Gelatin.* **S. O. Rawling** and **W. Clark.** (Chem. Soc., J. 121. pp. 2830–2843, Dec., 1922.)—Though the viscosity of a gelatin solution is at a minimum at the isoelectric point where pH = 4·7 at 35·4° C., Pauli and Samec found that as the concentration of gelatin increases that of the acid necessary to produce a minimum viscosity also increases. A confirmation of these results is obtained in the present work, and in addition it is shown that the pH is the same (4·7) for all solutions of minimum viscosity, including those with both sulphuric and acetic acid. In accordance with theory it was found that when a solution of gelatin made isoelectric with either of these acids is diluted to two or three times its volume its pH remained constant within the errors of experiment. In contradistinction to the deductions from Walker's theory for amphoteric electrolytes it is found that the amount of acid needed to give minimum viscosity and a pH of 4·7 increases as the concentration of gelatin increases. The existence of basic degradation products of the protein are considered to be the probable cause of this departure and also of the fact observed by Pauli that in some cases the point of non-preferential migration of proteins under the action of an imposed E.M.F. occurs at a pH above that at which minimum viscosity is obtained. On plotting the concentration of sulphuric acid necessary to give minimum viscosity against the concentration of gelatin, a straight line is obtained as found by Pauli, though the slope is different. The discrepancy is attributed to the use of different kinds of gelatin. J. N. P.

769. *Theory of Recrystallisation.* **H. Altherthum.** (Zeits. f. Metallkunde, 14. pp. 417–424, Nov., 1922.)—The paper commences by a brief review of the existing literature on the subject, and then discusses the thermodynamic analysis of the mechanism of the cold-working process for metals. The conception is raised of the various grades of worked products being a continuous series of differently orientated modifications, and the attempt is made to derive a formula for the number of nuclei during recrystallisation. Recent experimental work by Czochralski, Rassow and Velde, Oberhoffer and Oertel, Koref and Wolff, Hevesey, etc., considered in the light of the theory now developed, points to the formation of nuclei as the direct consequence of the appearance of new phases in the metal. The phenomenon of recrystallisation in metals is then treated as analogous to crystallisation from fusions, nuclei formation for allotropic transformations, and crystal formation by precipitation from a gaseous phase, where a re-arrangement of the atoms in the space-lattice has been established. The working process for metals is thus considered to bring about alterations in the lattice. Experiments with X-rays are urgently required for further elucidation. H. H. Ho.

770. *Diffusion in Solid Solutions.* **H. Weiss** and **P. Henry.** (Comptes Rendus, 175. pp. 1402–1405, Dec. 26, 1922.)—The diffusion of

gold into silver was studied. Couples of gold and silver were heated for times varying from 2 days to 32 days, at temperature of 835°, 885°, 935° C., and the penetration followed by examining sections micrographically. The relation between time and depth of penetration and the variation of the diffusion with temperature were followed. F. J. B.

771. *Separation of Gaseous Mixtures by Diffusion.* **G. Hertz.** (Phys. Zeits. 23. pp. 433–434, Oct. 15–Nov. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—A stationary diffusion process in a moving medium is investigated, in which the partial pressure of the gaseous mixture to be separated is small compared with that of the diluting gas, which forms an "adverse wind." It is essential to prevent the greater part of the mixture being carried away in the wind, and so a vapour is employed. Experiments showed that a short path and a high velocity are advantageous. With one single process it was possible to separate a mixture of helium and neon (30 % helium), using water-vapour, so completely that the spectrum of the helium obtained showed no neon lines in a direct vision spectroscope. It is hoped to apply the method to the separation of isotopes. A. C. M.

772. *Structure and Chemical Activity of Copper Films, and the Colour Changes Accompanying their Oxidation.* **C. N. Hinshelwood.** (Roy. Soc., Proc. 102. pp. 318–328, Dec. 1, 1922.)—In a specially designed apparatus, described and illustrated, copper foil is successively alternately oxidised and reduced with oxygen and hydrogen respectively at low pressures (1 mm. and 4 mm.), and at temperatures of 233° C., 302° C., and 400° C. Observations of the corresponding colour phenomena confirm previous conclusions that the colours produced are due to diffraction caused by minute granular structure of the surface film, and not to simple interference. In the oxidation experiments the brilliancy of the diffraction colours increases *pro rata* with the chemical activity, the granular film which most effectively scatters light presenting the largest surface to the action of the oxygen. The permanent colour sequence ultimately reached is purple, blue, green, yellowish green, purple, blue, black, and the ratios of the amounts of oxygen required for the attainment of the various colour stages are constant. With reduction no diffraction colours appear when a black film is reduced. A theoretical explanation of the results obtained is attempted, including a tentative calculation of the order of magnitude of the granules composing the film. A. B. C. L.

773. *Constitution of Aluminium-Zinc Alloys.* **W. Sander** and **K. L. Meissner.** (Zeits. f. Metallkunde, 14. pp. 385–387, Oct., 1922.)—This paper is a determination of the equilibrium diagram of the range 65 to 100 % aluminium in the aluminium-zinc series, and a comparison of the results with those of Bauer and Vogel and Hanson and Gayler [see Abstract 2160 (1922)]. The original must be consulted, as it does not lend itself to abstracting. F. J. B.

774. *Inverted Block Segregation.* **Kühnel.** (Zeits. f. Metallkunde, 14. pp. 462–464, Dec., 1922.)—The author discusses cases of the peculiar segregations of Bauer and Arndt [Abstracts 1761 and 2153 (1922)], which he had observed in railway workshops. In one case a plug of bronze, containing 85 Cu, 8·4 Sn, 4·8 Zn, 1·8 Pb, became coated on the outside with a layer containing 76 Cu and 18 Sn; different portions of the specimen varied strongly in strength. Inverted segregation seems likely to occur when the solidification has a large range at not too high a temperature. He does not quite agree with Bauer, and refers also to cognate cases observed by Wendt in steel. H. B.

775. *Fourth Report on Colloid Chemistry.* (Brit. Assoc. for Advancement of Science, Dept. of Sci. and Indust. Research [382 pp.], 1922.)—Among the subjects with which this report deals are the following: Cataphoresis (by E. F. Burton), molecular attraction and the physical properties of liquids (by E. Edser), membrane equilibria (by W. E. Garner), theory of lubrication (by W. B. Hardy), concentration of ores by flotation (by E. Edser), and the *rôle* of colloids in electrolytic metal deposition (by H. J. S. Sand). W. R. C.

776. *The Corrosion of Ferrous Materials.* **R. Hadfield.** (Inst. Civ. Eng., Proc. 214. pp. 83–171; Disc., 173–195, 1921–1922. Nature, 110. pp. 878–880, Dec. 30, 1922.)—This paper deals with the results of part of the research work of the Committee formed by the Institution of Civil Engineers in 1916, to investigate the deterioration of structures exposed to the action of sea-water. Fourteen types of ferrous material, including Armco iron, Swedish iron, wrought iron, carbon, cupriferous, nickel, and stainless steels, and cast-irons are being exposed to sea-action in various parts of the world to determine by quantitative measurement their relative resistance towards corrosion. Specimens of the metals were subjected to various mechanical tests, such as the Izod, Frémont, and Brinell tests, and tests were made to determine the effect of strain upon corrodibility. The results of the tests are detailed in an Appendix to the paper, and show very strikingly the enormous superiority in every way of the heat-treated over the untreated metal. Various particulars are given of the chemical analysis tests made upon similar specimens of treated and untreated metals, and photomicrographs of various sections are included, as it was anticipated that the microstructure of the metals would play an important part in their resistance to corrosion. The result of heat-treatment in reducing grain-size in the case of the wrought irons, was found to be reflected in the higher shock-test figures. The method of identification of the bars, for the corrosion tests, consisted in drilling holes in different positions in the ends of the bars, and in enveloping these ends in cement. The effects of strain and of the contact of dissimilar metals upon their corrosion is now being investigated. The non-corroding qualities of stainless steel used for the diaphragms of submarine hydrophones after several months of inversion in sea-water are described in this paper. A. W. J.

777. *The Pressures Developed in Gaseous Explosions.* **W. T. David.** (Engineering, 114. pp. 791–792, Dec. 29, 1922.)—Measurements were made of the rise of pressure with time during the explosion of mixtures of hydrogen or coal gas and air in varying proportions and under different conditions. The interior of the explosion vessel consisting of a plain cylinder of cast iron 12 in. in diameter and 12 in. in length with flat end-covers was silver-plated and could be made reflecting to incident radiation by polishing it or absorbent by coating it with a thin layer of dull black paint. Pressures were recorded on a revolving photograph film by means of a Hopkinson optical indicator.

For a given mixture, the time of explosion was least, and the maximum pressure developed greatest, when the spark was placed in the centre of the vessel. With rich mixtures of hydrogen or coal gas and air the maximum pressures were higher and were attained in a shorter interval than with weaker mixtures. The time of explosion was found to increase slightly with the initial pressure of the mixture and, as found by Petavel when employing high pressures, the ratio of the maximum to the initial pressure increases slightly with the latter. This is due mainly to the relative decrease in the heat loss during the explosion period as the pressure is increased.

With coal gas and air the maximum pressure is slightly greater and the rate of cooling much lower in the polished than in the blackened vessel. This is due to the radiation emitted by the hot gaseous mixture in the former case being reflected back by the walls and reabsorbed. With hydrogen and air the rate of cooling was also considerably less with the polished vessel, but in this case the amount of radiation emitted during the very short explosion period is very small, and the maximum pressure was found to be not appreciably greater than in the blackened vessel.

By replacing the nitrogen of the air in the explosive mixture by carbon dioxide, the maximum pressure developed is greatly reduced and the speed of combustion slowed down. These effects are proportional to the amount of carbon dioxide added and are due mainly to the greater specific heat of carbon dioxide compared with nitrogen. A further factor is that in the carbon dioxide mixture rather less of the coal gas is burnt at the moment of maximum pressure than in the nitrogen mixture. [See Abstracts 1080 (1906) and 593 (1922).] J. N. P.

778. *Solution of Metals in Acids as related to Corrosion.* **W. D. Richardson.** (Am. Electrochem. Soc., Trans. 38. pp. 245–278, 1920.)—Attention is drawn to the inconsistent behaviour of the metals in corrosion and acid solution phenomena on the basis of the electrochemical series. These inconsistencies can only be explained by taking into consideration a number of factors, the chief of which are solution tension, hydrogen, oxygen, carbon dioxide, halogens, and the kathode influence. The effect of catalysers in relation to solution was studied, some having a negative influence and others positive. W. R. C.

779. *Influence of Copper, Manganese, and Chromium, and some of their Combinations on the Corrosion of Iron and Steel.* **E. A. Richardson** and **L. T. Richardson.** (Am. Electrochem. Soc., Trans. 38. pp. 221–233; Disc., 233–244, 1920.)—The authors show that there is a mutual action between manganese and copper in their effect upon the atmospheric corrosion of iron. Copper alone reduces the corrosion of pure iron and, to a still greater extent, the corrosion of steel. If manganese is replaced by chromium the effect is still more pronounced. The effect of manganese and chromium on the red-short range in iron is also studied. W. R. C.

780. *Hydrogen Ion Concentration and the Properties of the Emulsoid Colloids.* **R. H. Bogue.** (J. Phys. Chem. 26. pp. 801–811, Dec., 1922. Paper read before the Am. Chem. Soc., April, 1922.)—It has been shown that the various physical properties of the emulsoid colloids, including the viscosity, jelly strength, melting-point, and joining strength, are at a minimum at a hydrogen ion concentration corresponding to the isoelectric point (pH = 4·7). As the acidity or the alkalinity of the solution is increased from this point, these properties rise in value. In the case of viscosity a maximum is reached at a pH value of 3·5, after which the viscosity falls with further addition of acid, while with the addition of alkali, a maximum is reached at a pH value of 9·0. The degree of swelling (or hydration) of gelatin in water is found, within certain limits, to be a parallel function with the viscosity in the same solvent, except that the percentage change in the swelling may be far greater than the corresponding change in viscosity for the same alteration in H-ion concentration. Hydration is to be regarded as a change through which the protein enters into physico-chemical combination with its solvent and the essentially different process of solution as the expression of an increase in the degree of dispersion of the colloid. It is found that a 1 % solution of pure gelatin in water at 10° C. remains solid within a range of pH values between 3·5 and 8·5, while in presence of amounts of acid or alkali outside this range the gelatin goes into solution. The observed phenomema have been accounted for on the basis of the Donnan law of equilibrium. A review is given of the results of measurements of the influence of the concentration of glue in the jelly and the H-ion concentration on the jelly strength, its viscosity and its setting and melting-point and the relation which these several properties bear to joining strength.

The greatest insolubility of gelatin occurs at the isoelectric point; consequently the maximum precipitation takes place at this stage when treated with salts. The importance of H-ion determination in the technical preparation of gelatin and glue is emphasised. J. N. P.

781. *Dust Explosions. A Colloid-Chemical Process.* **P. Beyersdorfer.** (Koll. Zeits. 31. pp. 331–333, Dec., 1922.)—A suspension of 6 grm. of sugar consisting of particles of 10^{-5}–10^{-6} cm. diam. in 10 litres of air can be ignited so as to give a violent explosion on bringing it into contact with a temperature of 410° C. With a lower concentration of sugar, however, explosion cannot be brought about even by exposing to much higher temperatures. The upper limit of concentration beyond which explosion is not obtained is as high as 135 grm. of sugar in 10 litres of air. This property of sugar is exhibited by suspensions in air of inflammable and organic substances generally, but below a certain definite concentration the mean path of separation of the particles is too great to enable the ignition to be propagated from one particle to another. In air suspensions, an important effect is exerted by the electrical charges on the particles which are of a greater magnitude than in the case of hydrosols. Air suspensions have the property of sols in showing the Tyndall-effect and opalescence, and the dispersion is facilitated by the electric charges. The higher the specific gravity of the disperse body the greater the electrical charge required to maintain the colloidal condition. By movement in the dispersion medium, air, the electrostatic charges are further increased and in proportion to the velocity of movement. If the electrical charge in relation to capacity of the particles exceeds a certain value, discharge takes place, whereby luminescence and chemical changes such as the production of ozone and nitrogen pentoxide are brought about. In some cases, instead of the silent discharge, electric sparks may be produced as with lightning discharges. In the case of inflammable suspensions these may lead to explosions. The violence of dust explosions is attributed to the colloidal nature of the suspensions. The greater the degree of subdivision of the particles the greater the relative amount of gases which are adsorbed on the surface, while oxygen is probably adsorbed in relatively larger amounts than nitrogen. J. N. P.

782. *Photochemistry of the Formation of Hydrogen Chloride. The Töpler Striæ Method for the Determination of Time Intervals.* **F. Weigert and K. Kellermann.** (Preuss. Akad. Wiss. Berlin, Ber. 24. pp. 315–320, 1922.)—Though H and Cl combine to HCl when exposed to light without contraction, there is a contraction in the presence of water, because the HCl is absorbed by the water. The first effect of exposure to light is, however, a slight expansion of the gas (Draper effect), generally considered a heat effect. Manometers being too sluggish for the study of this effect, the authors applied the striæ method of M. Töpler (1867). When a beam of light passes a sharp edge and then through an inhomogeneous medium, striæ are seen which can be photographed. The mixture of H and Cl is enclosed in a glass vessel closed by optical glass plates, and the illumination beam and the excitation beam are kept separate. With the aid of various filters for radiation of different wave-lengths, it was proved that a cloud and striæ, indicating formation of HCl and similar chemical reactions, were only observed when the exciting light was ultra-violet or blue; longer heat rays did not cause the formation of a cloud. The light sources (originally arcs, subsequently fine magnesium sparks in series) and the paths of the beams were then so arranged that the exciting sparks preceded the illuminating sparks. When the two sparks were simultaneous, no cloud and no striæ were seen; the striæ only appeared after an interval of about 1/300 second; this was confirmed by the aid of pendulum circuit-breakers. The striæ disappeared again, owing to the absorption of the hydrochloric acid formed, so that series of photographs could be taken at intervals of 5 seconds; the striæ are practically visible only for a period of 0·01 to 0·05 second. The experiments prove that the HCl reaction is an after-effect of the primary light-excitation. The direct radiation calls forth only a very slight reaction; the bulk of the hydrochloric acid is formed later. With that conclusion certain objections to Einstein's law of photochemical equivalence would fall. It had been objected that, particularly in the photochemical formation of HCl, a vastly greater number of molecules (10^6 per quantum) seemed to take part than the primary light reaction could account for. H. B.

783. *Decomposition of Hydrogen Molecules by means of Electrically Excited Mercury Atoms.* **G. Cario and J. Franck.** (Zeits. f. Physik, 11. 3. pp. 161–166, 1922.)—Franck has recently shown that electrically excited atoms should theoretically be able to give up their quantum energy to other atoms with which they collide, and revert to a lower quantum state without radiating light. The quantum energy may be divided amongst the mechanical degrees of freedom of the colliding atoms; if large enough it may produce a quantum increment in one of the electrons of the second atom; or it may provide the energy required for some chemical reaction [Abstract 2278 (1922)]. The sensitising of photochemical processes by the addition of some substance is an example of the third case; and experiments are described in which hydrogen was dissociated by the 2536·7 Å. mercury line when mercury vapour, which powerfully absorbs this line, was present. A quartz tube containing pure hydrogen, a little mercury, and some metallic oxide which is reduced by atomic hydrogen, was connected with a mercury pump, and placed in a small electric oven to raise the vapour pressure of the mercury. Light from a mercury lamp was focused by a quartz lens into the tube. Using powdered copper oxide, the reduced copper on the surface could be recognised by its colour; and the reduction in pressure of the hydrogen could be measured with a MacLeod gauge. The water formed was condensed in a side tube, by means of liquid air; and when this was taken away a rise of pressure was observed, which was removed by opening a tap connecting another side tube, containing phosphorus pentoxide, which absorbed the water vapour. Parallel experiments were carried out to show that no such results were obtained in the absence of hydrogen and of mercury; and it was found that the effect ceased when the mercury line underwent reversal, since it is only the very central portion of the line which is absorbed by mercury vapour. Curves were obtained showing the relation between the velocity of reaction and the pressure; these show that it is not possible to explain the observations by means of H_2 molecules, which have obtained velocities corresponding to high temperatures by collision with Hg atoms; in which condition they would be capable of reducing the copper oxide. To confirm the result, tungsten trioxide was substituted, as this is only reduced by H_2 at red heat. The oxide is a bright yellow powder, and when reduced appears steel blue or black; the colour change observed, which was undoubtedly due to atomic hydrogen, was very striking. H. N. A.

784. *Measurement of Electrode Potential Drop with Direct-Current and Alternating-Current Electrolysis.* **S. Marsh** and **A. E. Evans.** (Roy. Soc., Proc. 102. pp. 328–340, Dec. 1, 1922.)—The variation with time of the electrode potential drop of various metals (Pt, Au, Ni, platinum black) is examined both with alternating and direct current, with the electrodes acting as anodes, and also as kathodes. A detailed description is given of the arrangement of apparatus and the most suitable types of measuring instruments to be employed. The results obtained are represented in a series of graphs. An attempt is made to interpret the variations observed as being due to oxidation and occlusion phenomena within the electrodes. The conclusions confirm the results of a previous investigation [see Abstract 789 (1920)] on the volume of gases evolved during alternating-current electrolysis. A. B. C. L.

785. *A Determination of Absolute Single Electrode Potentials.* **A. Garrison.** (Am. Chem. Soc., J. 45. pp. 37–44, Jan., 1923.)—Reference is made to the work of Ostwald and of Paschen, where, by means of the mercury dropping electrode, the potential of the normal calomel electrode was first assigned a value of 0·56 volt. Billitzer obtains the value − 0·18 from measurements of isoelectric points of colloidal suspensions of metals. In the present work this determination was made by the following method: A light metal needle of a shape similar to that used in the quadrant electrometer was suspended over two intersecting glass partitions arranged so as to form four quadrants at the base of a glass vessel, the needle being suspended with its long axis directly over one of the glass partitions and approximately 2 mm. above it. Electrolyte was placed in the vessel so as to cover the needle. A round plate of the same metal as the needle covered the bottom of the vessel and was also divided into 4 insulated parts by the glass partitions. These metal quadrants were alternately connected and could be raised to any desired potential whereby a current was passed through the electrolyte and the needle exposed to an electric field. A horizontal torque was thus set up if the needle had a charge relative to the solution. A 0·1 N. calomel electrode with the syphon tube dipping into the electrolyte was used to complete the cell. It was found that the potential of the needle varied with the strength of the current, and the effect was shown to be due to the difference in the polarisation of the kathodic and anodic processes at the needle. The concentration of the metal ions in the solution was adjusted until, as shown by absence of movement of the needle, there was no electrical double layer at the surface. At this point the e.m.f. of the chain gives the absolute potential of the standard electrode. Employing a silver needle at its isoelectric point as a zero electrode, the value for the 0·1 N. calomel electrode is found to be between − 0·020 volt and − 0·10 volt, which is in agreement with the determination of Billitzer. J. N. P.

786. *Action of Light on Arsenic Trisulphide Hydrosol.* **R. V. Murphy** and **J. H. Mathews.** (Am. Chem. Soc., J. 45. pp. 16–22, Jan., 1923.)—The sol was prepared by adding an ice cold, saturated solution of H_2S to an equal volume of 0·2 % solution of As_2S_3, removing the excess of H_2S by bubbling H through, and then boiling. The increase of conductivity under the action of light was studied with constant temperature and illumination, the concentration of the sol and the periods of exposure to light being varied. The curves show that the rate of change of conductance increases slightly with decreasing concentration of the sol, this being explained as due to increased photochemical activity of the colloid per unit mass, caused by greater ease of dispersion in the more dilute sol. The reaction is explained, in accordance with the suggestion of Freundlich and Nathansohn, as a 2-stage photochemical oxidation of H_2S to colloidal sulphur and a thionic acid, followed by reaction between H_2S and the acid. The first of these substances is the stabilising electrolyte for the micelle of As_2S_3, and the second for that of S; and these colloids are precipitated when the electrolytes are destroyed. The increase in conductivity is due to the building up of the thionic acid, and after long illumination the reaction proceeds at such a rate that equilibrium is maintained, and no further change in conductance takes place. H. N. A.

787. *Potential Difference between Glass and Electrolytes in Contact with the Glass.* **W. S. Hughes.** (Am. Chem. Soc., J. 44. pp. 2860–2867, Dec., 1922.)—Previous work on the subject by Haber and Klemensiewicz is described and a diagram given showing the original arrangement of apparatus employed. A description, illustrated by a diagram, is given of the modifications introduced into the original arrangement of apparatus in the present work, which is undertaken to study the exact character of the curve representing the relationship between glass surface potential and hydrogen-ion concentration as measured by the hydrogen electrode, the possibility of the use of a glass-surface potential as a measure of hydrogen-ion concentration in cases where the hydrogen electrode cannot be used, as in the presence of strong oxidising agents, and the conditions under which glass-surface potential is not a reliable measure of hydrogen-ion concentration. It is shown that glass-surface potentials are established and maintained by the passage of electricity through the glass. Glass-surface potential is a linear function of hydrogen-electrode potential only through a limited range of values. Variations in glass surface potential may be used as the basis of an electrometric titration method in the presence of oxidising agents which render the hydrogen electrode useless. The presence of certain substances (strong salt solutions or gelatin solutions) other than hydrogen ions affects glass-surface potentials. The numerical results obtained are tabulated and illustrated by graphs. A. B. C. L.

788. *Faraday's Law at the Kathode.* **J. W. Richards.** (Am. Electrochem. Soc., Trans. 38. pp. 91–93; Disc., 93–95, 1920.)—The following question is put forward and discussed: Since the direct invariable relation between electrical current and chemical quantity subsists only at the anode, and the present theory of electric current postulates current passing, as negative electrons, only towards the anode, is it not logical and reasonable to assume that the direct relation between electrical current and chemical quantity is true only at the anode? W. R. C.

789. *The Validity of Ohm's Law for Electrolytes at very High Field Strengths.* **M. Wien.** (Phys. Zeits. 23. pp. 399–403, Oct. 15–Nov. 1, 1922. Paper read before the Deut. Physikertag., Leipzig, Sept., 1922.) —It is customary to regard the motion of electrolytic ions as very slow, and the author investigates the problem as to whether the velocity will grow proportionally to the force for much stronger fields than those usually employed, *i.e.* does Ohm's law still hold valid. Lenard from kinetic considerations concludes that for field strengths of 10^6 volt/cm., deviations occur for the H ion, which quickly grow according to the square of the field strength. The author is of the opinion that our meagre knowledge of liquid constitution demands an experimental proof for Lenard's conclusions; hence the present investigation. Experimental conditions are fully described and the basis of the method discussed. The difficulties attending the measurement of the resistance in such high fields (100,000 volt/cm.) are considered, and the method of surmounting them given in detail. The paper contains several diagrams of apparatus and data curves. The solutions employed for the measurements were of sodium chloride, sulphuric acid, and sodium chloride containing 47 % of cane sugar, with which to increase the internal friction of the solvent. From the results obtained the author concludes that up to field strengths of about 500,000 volt/cm. Ohm's law remains valid only up to 1 %, and he claims to have established a qualitative confirmation of the Lenard theory. H. H. Ho.

790. *Electrolytic Production of Hydrogen Peroxide.* **F. W. Skirrow and E. R. Stein.** (Am. Electrochem. Soc., Trans. 38. pp. 209–219; Disc., 219–220, 1920.)—The literature is briefly abstracted, followed by results of experimental decomposition of sulphuric acid, sodium or potassium acid sulphate solutions. The current efficiencies with which persulphuric acid was formed were about the same in all three solutions. Platinum was the only successful anode material. Distillation of persulphuric acid to form hydrogen peroxide was not successfully performed; distillation of potassium persulphate, once re-crystallised, gave reasonably high yields of hydrogen peroxide. In the case of persulphuric acid or sodium persulphate solutions, extremely rigorous purification of the solution would be necessary to remove suspended catalytic impurities before proceeding to the distillation. **Author.**

791. *Electrolytic Lead-Tin Alloys.* **W. Blum and H. E. Haring.** (Brass World, 10. pp. 302–304, Oct., and pp. 315–317, Nov., 1921. Zeits. f. Metallkunde, 14. pp. 303–304, July, and p. 436, Nov., 1922.)—In order to obtain non-corrosive deposits, especially for protecting the inside of the air-flasks for torpedoes, J. S. Groff (U.S.P. 1,364,051 of Dec. 28, 1920) electrolyses anodes of lead and tin (50 : 50) in an electrolyte produced by dissolving white lead in an aqueous mixture of hydrofluoric acid and boric acid with a little glue. The process was adopted by the U.S. Navy, and investigated by the authors in the Bureau of Standards and in works. They find that lead and tin have nearly the same potential in fluoborates, though tin has the higher solution pressure under similar conditions, and that Pb and Sn may replace one another. The bath efficiency is nearly 100 per cent.; the ratio of the two metals in the deposit depends upon their ratio in the bath; increased current density raises the Sn content of the deposit when the bath is poor in tin; addition of glue has the effect of increasing the current-density. The composition of the anode is important only in so far as it influences the composition of the bath; when the anodes contain more or less than 71 per cent. Sn, the tin contents of the deposit is influenced in the opposite sense. In order to obtain alloys of 50 Sn to 50 Pb a solution of half-normal HBF_4 should be electrolysed with anodes of tin, using later alloy anodes; the bath should be stirred; current density 0·5 to 1 amp./dm.^{2}. The alloy deposits are denser in structure than the deposits of the constituent metals, and the addition of glue renders the grain still finer. **H. B.**

792. *Transference Experiments with Hydroxylamines.* **W. A. Noyes and J. H. Hibben.** (Am. Chem. Soc., J. 45. pp. 355–359, Feb., 1923.)—A series of transference determinations were made with trimethylamine oxide, trimethylhydroxyammonium salts, trimethoxyammonium iodide and bromide, trimethyliodomethylammonium hydroxide, and trimethylethoxyammonium hydroxide. It was shown that in each case a hydroxy, methoxy, or ethoxy group remains with the nitrogen as part of the kation. The attachment of these groups to the nitrogen must be very different from that of the hydroxyl or other atom or group which travels toward the anode during the electrolysis. The resistance offered by the solutions of trimethylamine oxide hydrate, and of trimethylethoxyammonium hydroxide appears to be more consistent with the hypothesis that the hydroxyl ion of these compounds is attached to the nitrogen by a principal valence, of such a character that it is only slightly ionised, than with that of the unlocalised polar valence assumed by Lewis and Langmuir.

F. J. B.